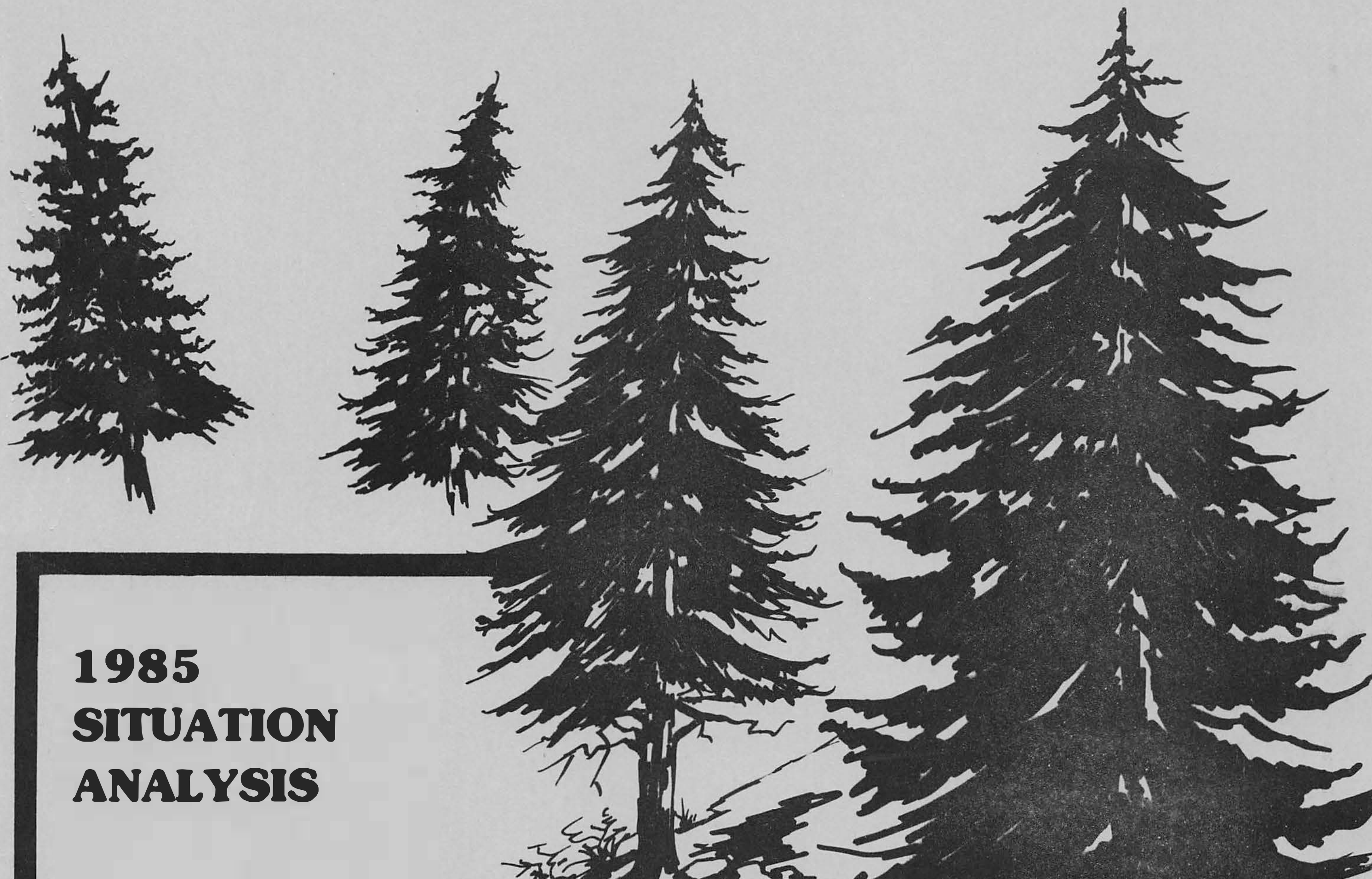
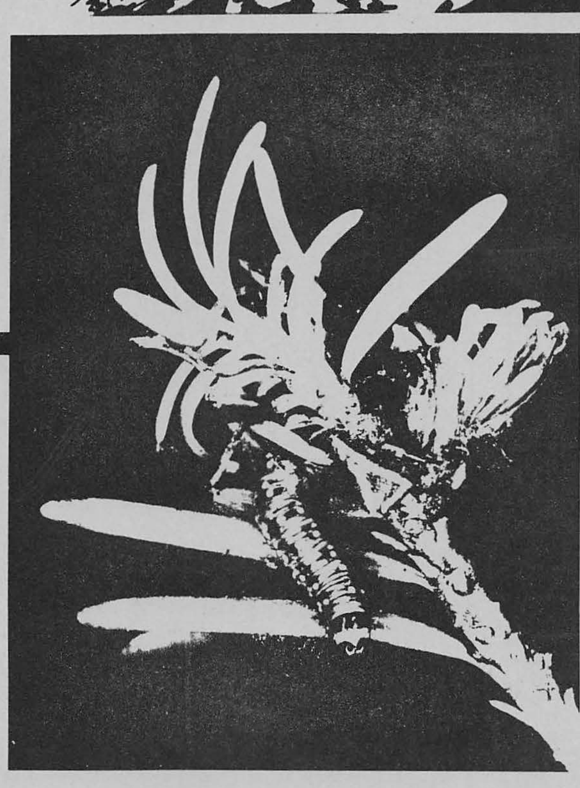
WESTERN SPRUCE BUDWORM
in the Northern Region



1985 SITUATION ANALYSIS

AUGUST 1986



Report 86-12

USDA - Forest Service
Northern Region

WESTERN SPRUCE BUDWORM IN THE NORTHERN REGION

1985 SITUATION ANALYSIS[1]

INTRODUCTION

The western spruce budworm[2] is the most widespread, persistent defoliator in the Northern Region. From about 1 million to 4-1/2 million acres of Douglas-fir and true fir forests in the Region have been defoliated by budworm each year for the last 35 years.

In 1977, all National Forests in the Region reviewed their budworm situation and management options and selected management alternatives. The composite of the Forest analyses makes up the Region's 1977 Western Spruce Budworm Management Plan Environmental Impact Statement.

Recognizing the seriousness of the budworm situation, the USDA Forest Service, in cooperation with the Canadian Forestry Service, in 1978 initiated a 6-year accelerated budworm research, development, and application program (CANUSA).

CANUSA's objective was "to design and evaluate management strategies for "control of the spruce budworm and/or management of budworm-susceptible forests...." With the completion of the CANUSA Program, and with other developments since the Region's Budworm Management Plan was prepared, it is now timely to reevaluate our current budworm situation and management direction.

Changes that have occurred since the 1977 Management Plan was developed include (1) registration of additional microbial and chemical insecticides for budworm suppression, (2) better understood and defined silvicultural approaches for reducing budworm-caused impacts, (3) changed resource values, (4) recognition of impacts on additional resources and availability of more data on the impacts of budworm defoliation, (5) improved methods of conducting economic analysis from those used in 1977, and (6) a stand hazard rating system based on stand and site characteristics.

<u>Objectives of a current situation analysis</u>--The objectives of this analysis are to:

1. Define the impact the western spruce budworm is having and is expected to have on the Region's management objectives, as determined by looking at two National Forests.

2. Define the options available in Forest planning for preventing and/or ameliorating budworm impacts.

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[1] Prepared by Cooperative Forestry & Pest Management; Planning, Programming, & Budgeting; and Timber Management, in cooperation with the Lolo and Gallatin National Forests.

[2] *Choristoneura occidentalis* Freeman

3. Assess the economics of direct suppression for budworm management strategies.

National concern--In August 1983, the Chief directed the Regions with western spruce budworm (1, 2, 3, 4, and 6) to identify and resolve, to the extent possible, any differences that may currently exist regarding budworm management philosophies. Of particular concern was the lack of uniformity in cost-benefit analyses and assumptions being made as to how much damage is acceptable under various management objectives.

During September 19-21, 1983, representatives from the Western Regions met in Ogden, Utah, in response to the Chief's directions. The major subjects dealt with were:

1. Reasonable alternatives and tone of these alternatives

2. Damage estimates with and without suppression

3. Methodology for economic analyses

4. NEPA documentation--EA or EIS

5. Worst-case analysis.

Results of this 3-day meeting are enclosed (Appendix A).

NATURE OF BUDWORM PROBLEM

The first reports of western spruce budworm in Region 1 were in the early 1920's. Defoliation was reported at that time from northern Idaho and central Montana. Until the late 1940's, our knowledge of budworm outbreaks in the Region came largely from ground surveys of very small entomological units and from Ranger District reports, many of which were sketchy. Some were suspect as to what pest species were being reported. Entomologists began a system of surveying and reporting budworm outbreaks for the entire Region in 1948 and by 1953 District Ranger budworm reports were terminated. From then to the present most of our budworm outbreak information has come from annual aerial surveys.

Since the initiation of aerial surveys on most National Forests (1950) until the present, about 1 million to 4-1/2 million acres have been defoliated annually. Forests with the largest and most persistent outbreaks have been the Gallatin, Lewis and Clark, Helena, Deerlodge, Beaverhead, and Bitterroot. Outbreaks have been less general and shorter lived on the Lolo, Nezperce, and Clearwater NF's, while the pest is infrequently a serious problem on the Flathead, Kootenai, and Idaho Panhandle NF's. Historically, most budworm infestations in the Northern Region (60-70 percent) persist for 1 to 5 years, whereas the remaining outbreaks have lasted from 6 to 20 years.

General impacts--The most quantifiable impacts of budworm defoliation are growth loss, tree deformity, tree mortality, and effects on regeneration. Less quantifiable impacts are those associated with esthetic quality, recreation, hydrology, wildlife, and fire hazard.

Tree growth is affected in a number of ways by budworm defoliation. Height growth is impacted by (1) destroying the terminal bud, thus producing no annual internode; (2) killing the top of the tree, thus destroying one or more internodes grown in previous years; (3) retarding height growth due to reduced overall tree vigor.

Several studies have shown insect defoliation can cause marked reduction in radial growth. In the current infestation in eastern Oregon, entomologists have found radial growth reductions of 12.2 percent in Douglas-fir and 27.3 percent in true firs. Moreover, radial growth reduction of 40-80 percent has occurred in some stands. Using a sample of R-1 defoliation levels and outbreak history, the CANUSA budworm damage model projected radial growth reductions between 20 and 60 percent based on defoliation levels. Much variation in reported impacts exists among studies of the budworms' impact on radial growth due to such things as the age and intensity of the infestation, productivity of the site, vigor of the stand prior to the infestation, etc. Missing rings, often associated with heavy defoliation, can confuse the interpretation of radial growth rates.

Several consecutive years of defoliation can cause top kill of host trees. After 10 years of defoliation in the more severely infested areas on the Lolo NF, up to 74 percent of the stems have been top killed. Stem deformity is another impact that often occurs as forks, crooks, or creases.

Budworm-caused mortality is usually light and frequently concentrated among the smaller suppressed trees. Tree mortality is highly variable among stands, often being clustered. In some stands tree mortality has exceeded 50 percent.

Budworm can affect cone and seed production by killing or weakening the cone-bearing portion of trees or more commonly by feeding directly on the developing flowers and cones. In Region 1 up to 100 percent of a cone crop has been lost in Douglas-fir stands where defoliation is moderate to heavy.

CURRENT MANAGEMENT STRATEGY

The Region is currently guided by the 1977 "Western Spruce Budworm Management Plan" regarding budworm-related decisions. In that plan, each Forest analyzed (1) its budworm situation, (2) management alternatives available, and (3) the environmental, economic, and social impacts of each alternative. They then selected a preferred action. The management alternatives evaluated were special silvicultural treatments, normal management practices (no direct action against budworm), and pesticides.

The preferred action for the Beaverhead, Bitterroot, Idaho Panhandle, Lolo, and Nezperce NF's was a combination of special silvicultural treatments and normal management practices. The preferred action for the Deerlodge, Flathead, Kootenai, and Lewis and Clark NF's was normal management practices. The Helena and Gallatin NF's selected combinations of all three alternatives.

Special silvicultural practices aimed at reducing budworm-caused impacts that are frequently addressed in prescriptions include:

- featuring even-aged systems wherever biologically sound and compatible with other management objectives,

- encouraging species diversity, but maintain two-thirds or more of the stand in seral species,

- in partial cuts, favoring seral species for leave trees and minimizing the number of species that are hosts of the western spruce budworm,

- making cutting units as large as possible to reduce edge effect of dispersing budworms,

- removing heavily defoliated trees during cutting, thinning, and clearing,

- enhancing the vigor of the stand to help better resist defoliation.

With the exception of an 18,000-acre pilot control project with the microbial insecticide *Bacillus thuringiensis* (B.t.) on the Deerlodge NF and the single-tree spraying and implanting with chemicals for protection of cone crops, insecticides have not been used in the Region for budworm control since the EIS was prepared in 1977.

HISTORICAL AND CURRENT REGIONAL SITUATION

The budworm situation in Region 1 is a result of many decades of budworm defoliation, subsequent damage and growth loss, and the budworms' response to changing forest conditions. Fire suppression and logging have altered the natural forest succession. These actions have allowed extensive areas to approach climax condition, and often make them more susceptible to budworm depredation.

There is a fairly complete record of budworm defoliation in Region 1 going back to 1948. Prior to that time, defoliation records are scattered and incomplete. During the period 1948 through 1985, total acres of budworm-caused defoliation have been high in Montana and northern Idaho (Table 1). During this period, defoliation has been less than a million acres only five times. In several years, defoliation has exceeded 4 million acres. Region-wide totals from Table 1 are summarized by reporting area (includes all forested lands within and adjacent to a National Forest) in Figures 1 through 16. Defoliation trends at the reporting area level have large fluctuations. Some outbreaks last for many years, others subside quickly. Levels of defoliation can vary from light to heavy in any type of outbreak. These fluctuations represent the budworms' responses to the specific climatic conditions, stand attributes, and natural enemy influences of the area. The current situation is shown in Figures 17 and 18. There were 2,715,129 acres defoliated in 1985 in Region 1, most of which was in Montana.

IMPACT ANALYSIS

Two Forests (Lolo and Gallatin) were selected as examples for the impact analysis. These Forests are on either side of the Continental Divide and represent a range of conditions with respect to budworm infestation, timber markets, and economic desirability of growing and managing timber. Forest planners evaluated all resources at risk on the Lolo NF and came to the conclusion that because of the tree species mix, stand densities, and ease of establishing regeneration, only timber resources were impacted by budworm defoliation, whereas on the Gallatin NF the values at risk were (1) timber, (2) regeneration, and (3) recreational visitor days (RVD) as influenced by changes in big game hiding cover.

Table 1.—Acres western spruce budworm defoliation in the Northern Region byh reporting area during 1948–1984.[1]

Year	Helena	L & C	Lolo	Bitterroot	Flathead	Kootenai	Deerlodge	Beaverhead	Gallatin	Custer	Yellowstone	Clearwater	Nezperce	St. Joe	Craig Mtn	Region 1
1948	261,560	0	0	0	0	0	0	0	0	0	142,500	0	0	0	116,500	261,650
1949	290,000	0	0	0	0	0	90,000	0	2,360,000	0	0	0	25,280	0	0	431,280
1950	290,000	50,000	0	0	218,000	0	0	26,000	0	0	0	10,600	12,480	0	7,080	714,160
1951	560,000	100,000	31,600	12,000	235,000	0	120,000	0	80,000	0	3,000	23,700	20,500	0	9,200	1,195,000
1952	583,040	194,790	209,480	123,140	23,320	0	297,480	17,560	180,080	0	15,720	80,380	58,620	0	129,440	1,913,050
1953	565,500	202,400	243,500	140,300	59,900	0	269,600	31,600	304,500	0	22,000	80,400	42,600	0	138,400	2,100,700
1954	680,250	66,600	185,580	126,020	60,050	0	278,000	110,850	2,379,900	0	55,410	86,700	38,800	0	171,500	2,239,740
1955	842,260	408,420	175,540	179,510	870	0	490,470	372,890	579,670	0	60,840	101,910	70,790	0	89,480	3,472,650
1956	900,430	535,510	296,600	298,200	2,500	0	525,200	506,140	936,700	0	142,500	119,370	83,700	0	60,000	4,416,850
1957	950,784	565,457	313,876	2,640	9	565,129	534,444	989,083	0	150,469	150,469	126,045	88,380	0	63,355	4,663,848
1958	1,112,119	728,514	391,414	426,851	1,385	0	559,176	405,387	899,871	0	88,961	118,123	46,377	0	116,506	4,894,684
1959	1,226,390	863,584	454,143	523,243	9	0	525,252	249,878	761,705	0	20,006	103,964	0	0	166,523	4,894,688
1960	658,990	464,040	244,030	281,160	0	0	282,240	134,270	465,160	0	10,750	0	0	0	89,480	2,630,120
1961	752,140	576,450	374,970	276,870	0	0	305,870	110,140	411,960	0	9,500	0	0	0	3,220	2,821,120
1962	831,610	527,090	428,350	324,830	0	0	308,180	83,490	385,440	0	5,490	0	0	0	1,030	2,895,960
1963	441,170	317,230	351,200	351,770	0	0	158,650	88,890	291,290	710	1,050	0	6,500	0	1,700	2,010,160
1964	546,780	389,450	342,110	247,030	0	0	99,310	130,430	254,380	3,720	3,310	0	166,610	0	2,680	2,185,810
1965	546,780	617,270	507,060	466,400	0	0	47,760	87,520	468,480	0	2,560	0	566,350	0	0	3,310,180
1966	316,080	324,750	345,320	335,245	0	0	22,180	96,220	261,650	9,170	7,630	33,870	571,400	0	0	2,323,415
1967	316,080	32,230	1,142,020	203,890	5,390	0	430	19,360	54,820	6,080	12,700	127,250	592,020	0	0	2,512,270
1968	465,960	157,100	1,584,170	394,900	87,000	0	58,800	11,500	187,300	50,400	22,700	240,600	1,310,100	0	0	4,570,530
1969	374,530	75,340	1,554,560	383,670	119,370	0	96,230	20,170	58,750	11,310	5,610	294,140	1,008,380	15,510	0	4,107,570
1970	32,000	0	1,042,000	465,000	224,500	0	204,800	17,585	37,005	0	2,000	360,000	1,300,000	28,000	0	3,712,890
1971	377,280	0	1,260,000	175,000	361,000	0	285,680	15,000	15,260	0	46,080	378,000	1,337,000	42,560	0	4,292,860
1972	385,000	0	1,350,000	321,000	383,500	0	335,000	21,000	15,260	2,925	46,000	397,600	1,342,000	66,500	0	4,665,785
1973	44,680	350	931,000	347,000	239,650	0	78,320	14,500	11,400	0	17,280	414,680	1,321,000	146,000	0	3,565,860
1974	259,752	18,534	1,033,440	262,998	215,552	9	268,237	48,770	54,026	0	39,933	591,479	1,182,823	204,841	0	4,180,385
1975	473,937	7,367	1,000,600	402,504	216,924	3,606	271,629	240,990	337,929	0	111,972	634,830	644,940	189,617	0	4,536,845
1976	313,161	5,927	820,330	413,641	167,957	9,685	223,666	250,427	286,325	5,155	114,572	358,070	107,050	190,591	0	3,266,557
1977	462,979	116,499	947,941	451,495	183,965	20,029	183,207	173,250	427,990	7,370	79,330	286,407	184,315	176,454	0	3,701,231
1978	575,151	176,294	281,161	379,112	65,737	14,604	382,762	223,720	293,265	3,265	104,694	8,115	4,590	7,416	0	2,520,246
1979	46,375	211,493	335,312	95,332	5,326	1,438	402,638	349,889	325,921	5,373	75,525	0	0	0	0	2,271,422
1980	3,630	57,112	36,492	4,710	0	0	27,004	179,215	510,119	30,910	125,960	320	0	600	0	976,072
1981	56,344	60,673	141,054	4,330	16,962	0	120,715	369,688	110,308	14,639	37,240	175	0	0	0	932,128
1982	232,987	88,560	328,496	390,036	80,892	0	198,453	532,038	331,288	32,085	41,476	0	0	0	0	2,256,311
1983	366,234	180,684	308,625	219,610	10,772	0	205,833	575,789	632,877	68,780	44,221	0	0	0	0	2,613,425
1984	581,372	206,104	86,880	33,969	1,750	0	322,467	345,650	574,165	110,132	52,283	0	456	0	0	2,315,228
1985	757,029	281,111	40,664	25,106	6,295	0	326,375	337,157	574,165[2]	90,550	29,155	0	1,995	0	0	2,715,129

[1] Acres includes Federal, State, and private lands.

[2] The Gallatin National Forest was not flown in 1985. Acres in 1984 used as observation showed little change from 1984.

The areas impacted by budworm feeding were determined by constructing overlays of historic aerial survey maps. Areas that suffered defoliation for 3 or more years, from 1975 to 1983, were identified. Those areas having less than 3 years of defoliation were not considered because little growth reduction or mortality generally occurs during the first 2 years of defoliation. Figures 19 through 21 show areas where 3 or more years' defoliation occurred on the Gallatin and Lolo NF's.

Forest planning has identified areas for timber harvesting. This information contains stand composition and is available in a data base system. Only the areas planned for timber harvest were used as basic analysis units for loss calculations. An overlay map of budworm-damaged areas was then used to identify the timber resource scheduled for harvest that was impacted by the budworm.

GROWTH LOSS ESTIMATES

Growth loss is the major timber impact of the spruce budworm. Many evaluations have shown radial growth reductions; however, this must be translated into periodic growth loss which is usually less than radial growth loss. Past surveys have shown that stand growth is reduced by about 24 percent per year from potential PAI[3] in defoliated stands, but will vary about this mean depending upon elevation, stand and site characteristics, and age and intensity of the outbreak. Growth loss information was obtained from 99 stands where both radial and height growth effects were measured and used to arrive at the 24 percent loss used for this analysis (Beveridge and Cahill 1984; Bousfield and Williams, 1977). This was accomplished by modifying the growth functions in the PROGNOSIS Model and other height diameter growth models based on field measurements. For both the Lolo and Gallatin NF's, the forest planning data base was utilized. This data base contained the necessary information as to growth rates, acres, forest type, and elevation in the impacted areas. On the Lolo NF, growth rates (PAI) used in the Forest Plan were determined by empirical data. Since a portion of the inventory had a history of budworm, the empirical data would reflect some loss already. A historical spruce budworm defoliation review was done to determine what percent of the known locations of the inventory sample units would reflect depressed growth based on past budworm feeding. To eliminate bias and not double count the loss, the percentage of inventory data with a budworm history (50 percent) was applied to correct potential growth estimates. Potential yields were then calculated as potential growth = current PAI/(1 - .50[4] * .24[5]).

On the Gallatin NF this bias was not a major factor because the Forest Plan used growth rates from PROGNOSIS[6] model projections. An attempt was made to screen out the effects of budworm and feeding by eliminating damaged and defoliated trees during PROGNOSIS model construction. A list of areas that the Lolo and Gallatin NF's planned to enter with a scheduled harvest was determined or estimated. Growth loss equations were then applied to the expected growth rates for these areas. Harvest methods were predicted so the appropriate costs could be applied.

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[3] Periodic annual increment without effects of spruce budworm.
[4] Percent of emperical growth data with effects of spruce budworm.
[5] Growth loss percentages expected to have occurred.
[6] Timber growth and yield model.

IMPACTS OF BIG GAME HIDING COVER ON THE GALLATIN NATIONAL FOREST

The Gallatin NF recognized that hiding cover for big game is an important resource that can be impacted by budworm defoliation. Thus, an analysis was made to quantify these effects. Adequate hiding cover is defined as a density of trees (stems and foliage) that will prevent more than 10 percent of a big game animal from being exposed at 200 feet.[7] A potential effect of reduced hiding cover is a shorter hunting season. Shorter seasons translate to reduced hunter opportunity days.

Forest planning on the Gallatin NF uses a model provided by Montana Department of Fish, Wildlife, and Parks to predict changes in hunter days when a change in percent forest cover and road density occurs.

To measure cover for the forested areas, we used PROGNOSIS on a sample of 15 stands selected to represent the impacted areas. PROGNOSIS has a cover option that calculates the sum of the stem diameters in feet and the area of foliage by 10-foot height classes (Moeur 1981). A translation from the PROGNOSIS output was made using the required density of 190 lineal feet of stems and foliage per acre. This is a standard for the Gallatin NF (Gilbert[8]). The cover model outputs of PROGNOSIS provided the sum of stems and the area of foliage below 10 feet on a per acre basis. We used one-half the width of foliage below 10 feet to account for the fact that some light would also pass through the branches. Hiding cover distance was calculated for each stand and acres not meeting the 200-foot distance were determined. These procedures were repeated to reflect what the situation might be if budworm were not present this decade. The tree list from the sample stands was modified to reflect what trees, if any, would be missing because of budworm. Evaluations of permanent plots from 1979 to 1982 were used to estimate mortality rates. The following equation explains expected Douglas-fir mortality by tree diameter (Bousfield and Chase 1982).

$$Y = ax^{b}e^{cx}$$

Where Y = probability of 3 years mortality (percent of trees that died in that diameter class):

a = 0702
b = 1.7752
c = -.5501
x = tree diameter in inches
e = natural antilogrithim

These rates were then applied to the existing diameter distribution of Douglas-fir to approximate what would have been there 10 years ago. From this analysis, the number of trees needed in each tree list ranged from one to four, depending on the number of plots and diameter distribution of Douglas-fir trees on sample stands. One 2.9-inch diameter and one 4.9-inch diameter tree were then added to each tree list to simulate the no-budworm situation and the cover model was rerun. Number of acres not meeting the standard of 200 feet was computed to reflect the no-outbreak situation (Table 2).

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[7] Standard used by the Gallatin NF Forest Plan.
[8] Personal communication with Alfred Gilbert, Gallatin NF Timber Staff Officer.

Table 2.--Forested acres by hiding distance.

A. With spruce budworm

hiding cover distance <50′	50′-100′	100′-200′	>200′	Total acres infested[1]
acres				
57,067	171,200	85,600	114,133[2]	428,000

B. Without spruce budworm

hiding cover distance <50′	50′-100′	100′-200′	>200′	Total acres infested[1]
acres				
57,067	171,200	171,200	28,533[2]	428,000

[1] Includes all ownerships.
[2] Acres not meeting hiding cover standards.

The wildlife model requires percent of area not providing adequate cover which includes nonforested acres or PI type 93[9] in the Forest inventory. A sample of compartments in the impacted area was analyzed to determine percent forested. This analysis found that 83.5 percent of the Gallatin NF in the impacted area was covered by trees. A total of 428,000 acres of forested lands on all ownerships was impacted within 3 to 20 years on the Gallatin NF (Table 3). Using 83.5 percent forested, this translates to 84,530 acres of open area. Percent cover with and without budworm is shown in Table 3.

The hiding cover model predicts change in hunter/visitor days when current hunter days, road density, and percent cover are known. Montana Department of Fish, Wildlife, and Parks has provided Forest planners with data taken in 1980 to show visitor days by hunting district within the Gallatin NF (Table 4) (Fig. 22). Since the entire hunting district was not impacted, the percent of each hunting district that was included in the budworm area was calculated.

Currently there are 15,160 hunter/visitor days in the spruce budworm-impacted area (Table 5). If budworm had been absent or controlled, there would have been 17,648 hunter/visitor days, or an increase of 2,488 days (Table 5).

Hunter opportunity index (HOI) is obtained from Appendix B when the percent cover and road density is known. Road density used in the Forest Plan was one per square mile.

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[9] Photo interpretation class for nonforested areas.

Table 3.--Percent of cover with and without budworm.

With budworm (current situation)

Nonforested	+	inadequate cover	=	non-cover
		..........acres..........		
84,530	+	114,133	=	198,663

Percent cover =
(1-(198,663 / 512,530)[1])*100 = 61.2%

Without budworm

Nonforested	+	inadequate cover	=	non-cover
		..........acres..........		
84,530	+	28,533	=	113,063

Percent cover =
(1-(113,063 / 512,530[1]))*100 = 77.9%

[1] Acres of defoliated area that includes nonforested areas.

Table 4.--Number of hunter days in spruce budworm-impacted areas.

Hunting unit	National Forest hunter days[1]	National Forest impacted acres by hunting dist.	Percent of National Forest in impacted area[2]	National Forest hunter days impacted
301	9,766	38,704	29.5	2,879
310	8,360	15,750	11.5	959
311	5,017	25,381	25.1	1,261
312	10,607	14,820	24.8	2,629
313	7,911	24,908	28.0	2,218
314	13,332	16,102	17.0	2,277
315	5,512	13,545	25.5	1,403
317	4,374	18,077	11.8	517
560	2,326	2,023	1.7	39
561	1,020	6,494	5.9	60
562	1,555	32,546	56.9	885
582	292	4,339	11.3	33
		212,689		15,160

[1] For both elk and deer obtained from Forest planning document.
[2] National Forest acres in impact area by hunting district = percent National Forest impacted.

Table 5.--Hunter Opportunity Index and expected hunter days.[1]

With spruce budworm (current situation)
When cover is 61.2 percent, HOI = .67[2]
Current hunter days = 15,160 when HOI = .67
Without spruce budworm (if defoliation had not occurred)
When cover is 77.9 percent, HOI = .78[2]
Expected hunter days = 15,160/.67 * .78 = 17,648
Difference = 2,488 hunter opportunity days lost for 212,689 acres

[1] Hunter days on National Forest impacted area (212,689 acres)
[2] Obtained from planning document (Reid 1982)

ECONOMIC ANALYSIS

The economic analysis focuses on the expected losses associated with actual spruce budworm infestations that have occurred in the past decade (1974-1984). For comparison purposes in the economic analysis, it is assumed that a single spray application would have been necessary at the midpoint of the past decade (1979) to prevent these losses. All dollar values of costs and benefits in this analysis are expressed in 1984 dollars with adjustments to the base year mode using the GNP implicit price deflator.

From an analysis standpoint, we are doing an after-the-fact analysis of an infestation that actually occurred, and determining the costs and benefits as they would have appeared to the decisionmaker in 1979.

Assuming that the relationship between expected losses, magnitude of the infestation, and cost of spraying is the same, the results of this analysis would be applicable to a suppression program proposed for the current time.

Lolo NF Analysis

Only timber values were considered at risk on the Lolo NF. The Lolo Timber Sale Economic Analysis System was used to estimate the financial losses from the experienced spruce budworm infestation. The following assumptions apply:

- Capability areas infested with spruce budworm scheduled for harvest in the first decade are assured to be cut in 1985 (based on the decade from 1974 to 1984).

- Other infested capability areas are assumed to be harvested as follows:

Condition class	Harvest year
Poles	2060
Immature sawtimber	2030
Mature sawtimber	1995
Multistory	1995

All costs, values, and real price increases as used in the Lolo NF Forest Plan were used. All other management assumptions are also the same as used in the Forest Plan. The weighted stumpage value for the Lolo NF Forest Plan is shown in Appendix C. This analysis is from the perspective of making a decision in 1979.

Summary of present value (1984) of loss from spruce budworm on the Lolo NF:

Present value loss in 1984 $	$7,976,826
1979 value (discounted 5 years at 4%) in 1984 $	$6,556,370

Summary of spray costs. Assuming one complete spraying of the entire impacted timber base (594,450 acres) would be necessary with spray costs of $12/acre.

1979 spray costs (in 1984 $) 594,450 x $12 = $7,133,400

$$\text{Ratio of benefits to costs} = \frac{\$6,556,370}{\$7,133,400} = .92$$

Present net value = -$577,030
Breakeven cost: $11.03

Timber loss estimates assume that if the spray program is 100 percent effective in saving growth loss, the infestation could be controlled with spraying only the infested acreage, and if the costs were $11.03 per acre or less (in 1984 $), then it would have been economically efficient in 1979 to control the budworm.

Gallatin NF Analysis

In addition to timber losses, the Gallatin NF included regeneration difficulties and loss of hiding cover for wildlife. Each kind of loss is summarized separately and summed for comparison with spray program costs.

Reduction in Timber Volume

Planned sales for the first decade were analyzed and costs and benefits compared for "budworm with control" and "budworm without control" scenarios. Costs, prices, and management strategies updated from the Forest Plan were used. Timber price projections from the Forest planning analysis were used (the Lolo also used Forest Plan price projections for timber).

Future decades were also analyzed on the basis of the assumption that the same proportion of suitable land and volume scheduled for harvest has been infested by the budworm. All costs and benefits were discounted to the present and expressed in 1984 dollars. Weighted stumpage value for the Gallatin NF Forest Plan was $44.69/mbf.

1979 stumpage value in 1984 $ $214,888

Loss from First Decade Added Regeneration Costs

Present value of loss in 1984 $	$795,812
1979 value in 1984 $	$662,541

Regeneration savings which occur because cones will not be destroyed by the spruce budworm are projected for the first decade only without spruce budworm control. Forest silviculturists assumed that all Douglas-fir stands will need to be planted and 20 percent replanted. With budworm control, it is assumed natural regeneration will be adequate on 80 percent of the sites and only 20 percent will need to be planted.

<u>Loss From Big Game Habitat Decline</u>

RVD´s for hunting were valued on the basis of the 1985 RPA. These losses are expected to occur in the first decade only. An RVD value of $25.72 was used for this analysis.

RVD´s annual loss on the Gallatin was 2,488 days for 212,689 acres[10]
(2,488 days x 10 years x $25.72 = $639,829)

Present value of loss in 1984 $	$639,829
1979 value in 1984 $ (discounted at 4% for 5 years)	$525,893

Summary of predicted losses due to spruce budworm:

A.	Timber harvest loss	$214,088
B.	Added regeneration cost	662,541
C.	Loss of hunting opportunity	326,054[11]
	Total loss	$1,202,683 (1979 value in 1984 $)

Summary of spray costs:

Assume one complete spraying of entire area will be necessary. (Since the 65,547 acres in the affected timber base are scattered across the Forest, it is assumed it will be necessary to spray 2 acres for every acre actually impacted (65,547 x 2 = 131,094).

1979 cost (in 1984 $) = $131,094 x $12 = $1,573,128

Ratio of benefits to costs = $\frac{1,202,683}{1,573,128}$ = .76

Present net value = -$369,645

Break-even cost: $9.18

Break-even cost without wildlife benefits: $6.69

Assuming 100 percent effectiveness of the spray program in preventing losses, $9.18 per acre could be spent to control budworm ($6.69 if wildlife benefits are not included).

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[10] National Forest acres impacted for 3 or more years.
[11] Hunter opportunity value on 131,094 acres.

FOREST PLANNING

Presently, Region 1 Forests have not considered direct spruce budworm impacts in the planning process. Indirectly, the budworm impacts are of an implied nature through the FORPLAN model yield tables, which in turn has an indirect result in the Present Net Value of every alternative solution. Since little spraying has occurred in the past 10 years, control costs have not been included in the economic tables.

Existing yield tables in the FORPLAN model were developed using the empirical approach. Examined stands containing effects of past outbreaks were used to develop the empirical yield tables. Since the Forests did not plan to spray for budworm infestation during the present life of the plans (or over the planning horizon), no existing yield tables or economic tables were developed to show effects of the budworm.

CANUSA was just starting up at the time the yield tables for the FORPLAN model were being developed. Therefore, little or no data was available on reducing budworm impacts by silvicultural practices, much less any increased yields associated with these practices.

Regenerated yield tables were developed using the growth prognosis model. Functions in this model were derived from existing Forest inventory stands plus other research plots.

Inherent in these functions may be some growth loss even though the data was carefully screened to eliminate those trees with budworm damage. Inventory instructions called for recording spruce budworm only if it was present at the time of the data collection. Therefore, any budworm damage or infestation from earlier years before the data was recorded was not noted. The result is that trees with reduced growth slipped into the data used in developing the growth functions. The Forest Plans do not include economic effects of spruce budworm.

The principal direction to control insect outbreak in most Forest Plans is usually found under the Forest Standard section. Very little specific direction to forest pest problems can be found under individual Management Areas within a Plan.

Most Forest Plans for pest management prescribe silvicultural systems as the basic method of control. This is accomplished during regular timber harvest and no additional costs are incurred. These include improving species diversity (avoiding monoculture), maintaining stand vigor and growth, developing size class diversity between adjacent stands, maintaining single-storied stands, and reducing rotation ages to prevent losses.

Site-specific uses of chemical and biological control measures can be utilized when detailed analysis provides justification, often to protect resources other than timber. Examples are loss of cover for wildlife, visual effect along scenic routes, and enhancing recreation sites. These site-specific uses will be specified in the Management Area prescriptions.

CONCLUSIONS AND RECOMMENDATIONS

The western spruce budworm has been a pest of western forests for many decades. Prior and present forestry practices (fire suppression and harvesting aimed at seral species) may actually be promoting outbreaks. Silvicultural conversion of stands to a less susceptible state offers the greatest hope for preventing outbreaks or reducing the severity of impacts. However, this is a long-term approach and one that is not possible in all areas due to various constraints. Hence, we expect the budworm to be an important forest management problem well into the future. Direct suppression is the only way to manipulate existing outbreaks in most situations.

Our analysis has shown that the amount of budworm-caused damage varies markedly from Forest to Forest and even sometimes from drainage to drainage within a Forest. This variation is tied to differences in resources present and impacted, and frequency, duration, and intensity of outbreaks as influenced by stand, topographic, and climatic characteristics. Hence, the feasibility of any management action, e.g., direct suppression, stand manipulation, etc., must be assessed on a site-specific basis. This would make a programmatic NEPA document of limited value.

The two sample Forests used in this analysis reveal that the costs of direct suppression are only economically justified if they are less than $11.03 per acre for the Lolo National Forest and less than $9.18 per acre on the Gallatin. Differences are attributed to values at risk and the distribution of the timber base.

We make the following general recommendations:

1. Each Forest should review its current budworm management plan (1977 EIS), and gauge its present appropriateness.

2. Any Forest Plan revisions should include yield tables with and without budworm effects.

3. The Region's management team should determine if budworm management policy and direction should be developed to encompass the Region or on a Forest basis.

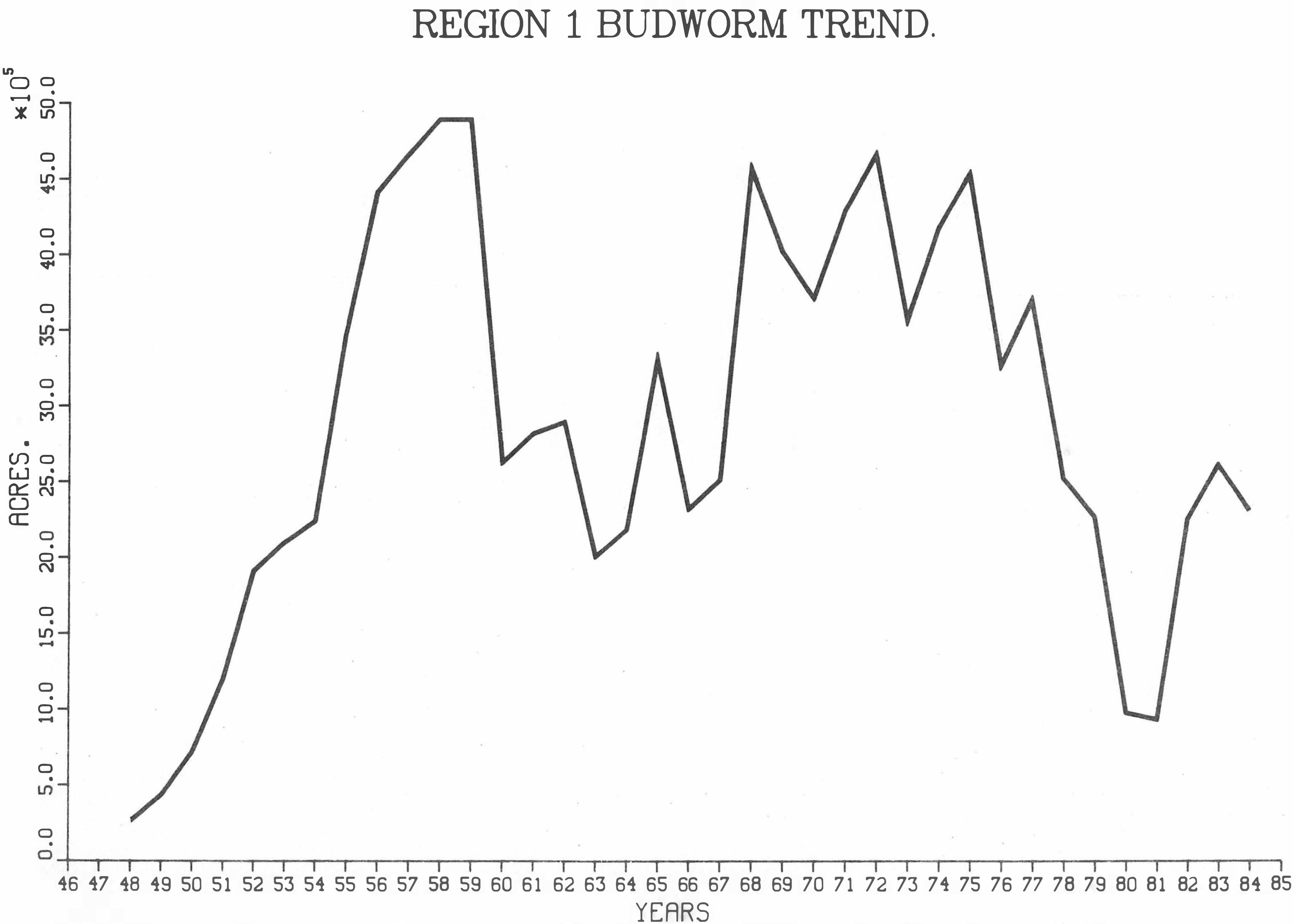

Figure 1. Acres of Western spruce budworm defoliation in Region 1, 1948 thru 1984.

BEAVERHEAD REPORTING AREA

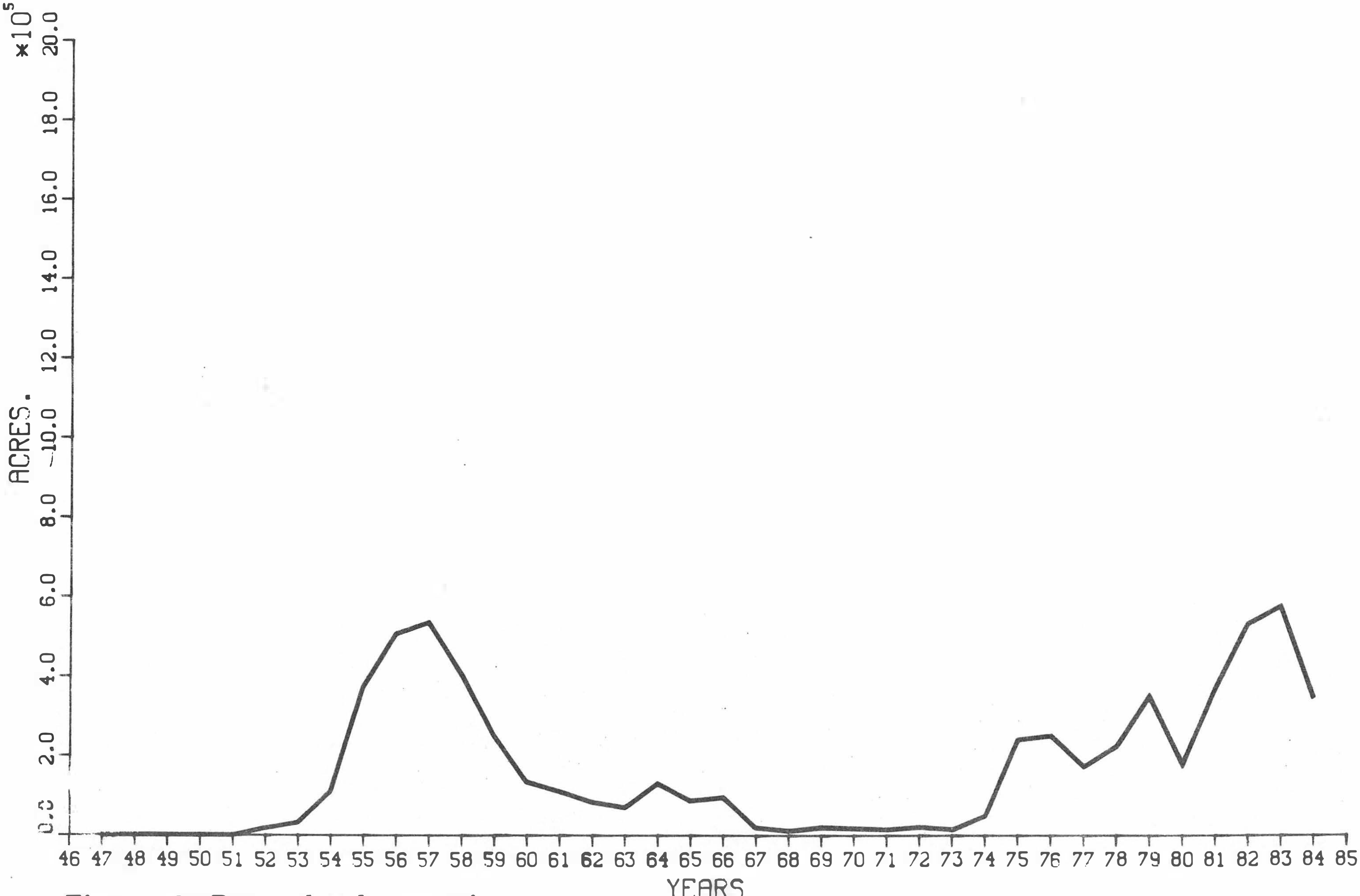

Figure 2. Beaverhead reporting area.

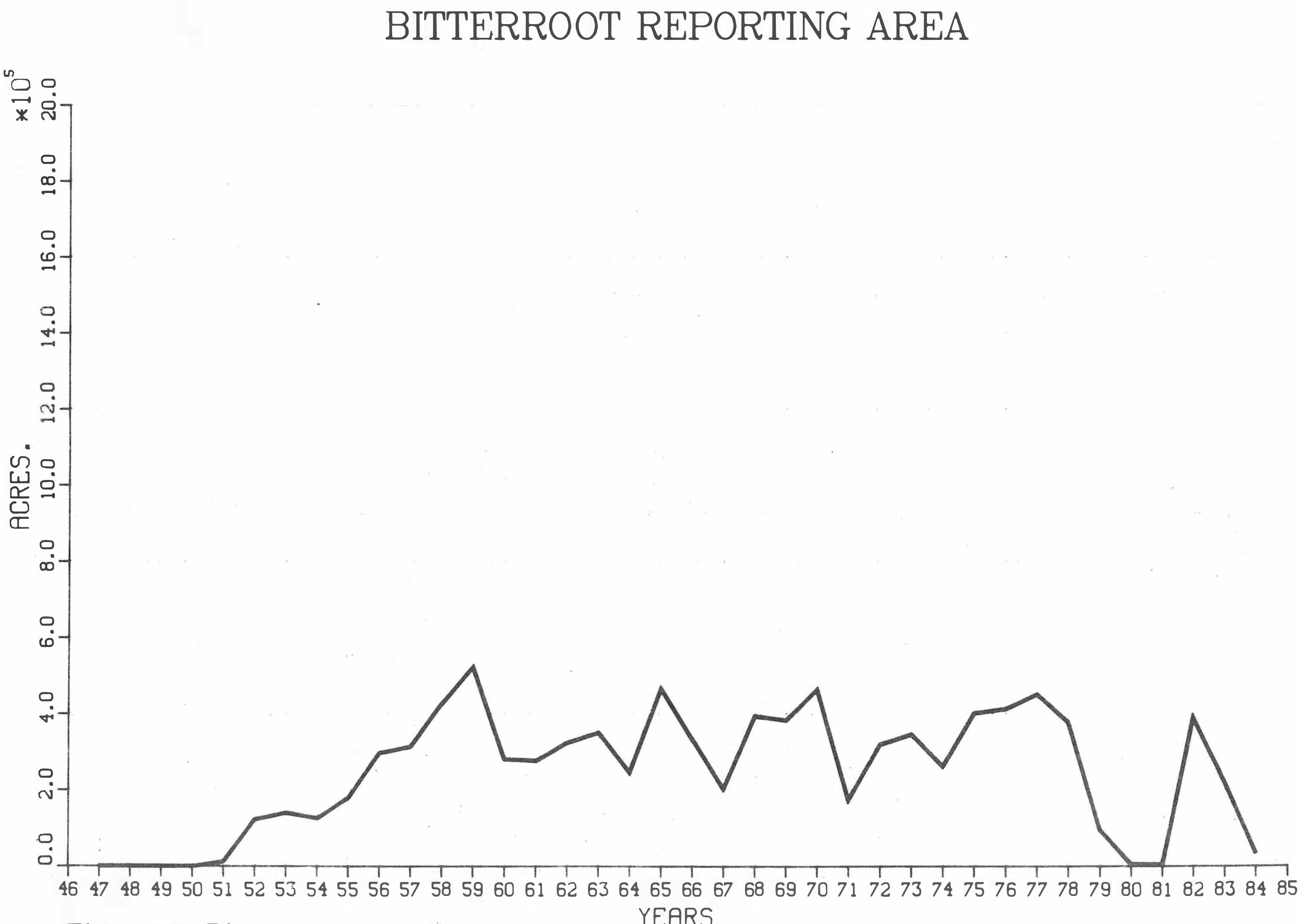

Figure 3. Bitterroot reporting area.

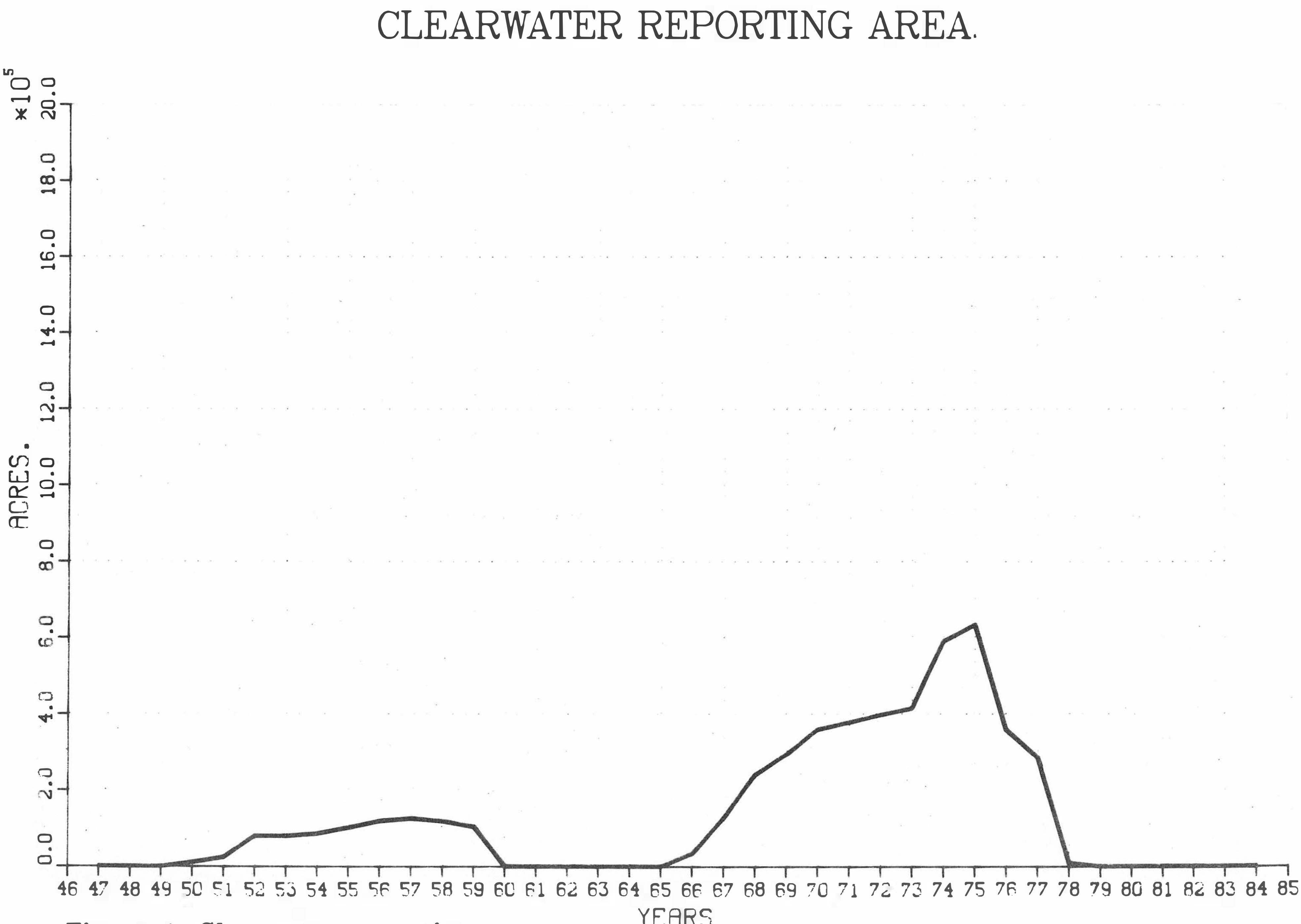

Figure 4. Clearwater reporting area.

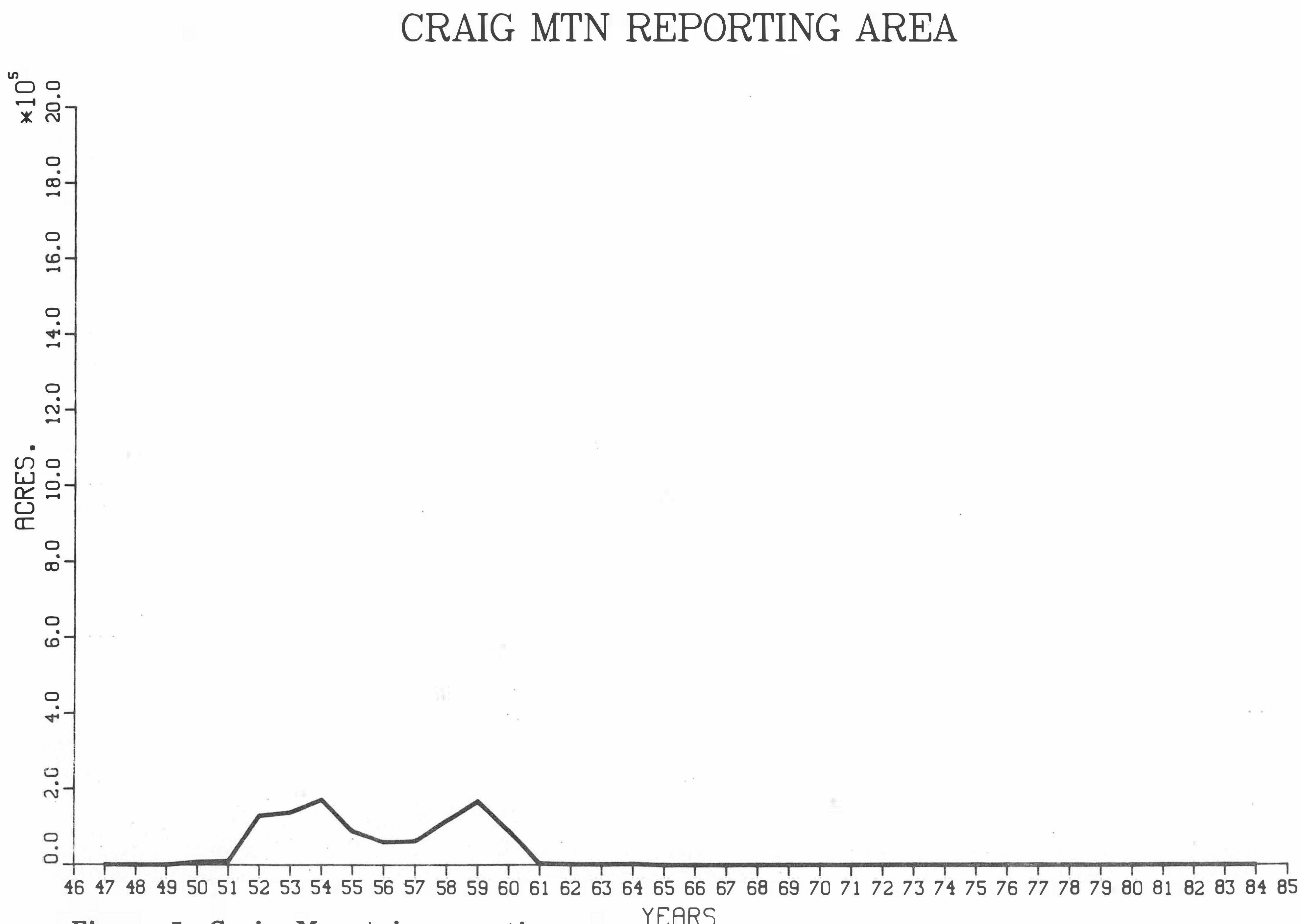

Figure 5. Craig Mountain reporting area.

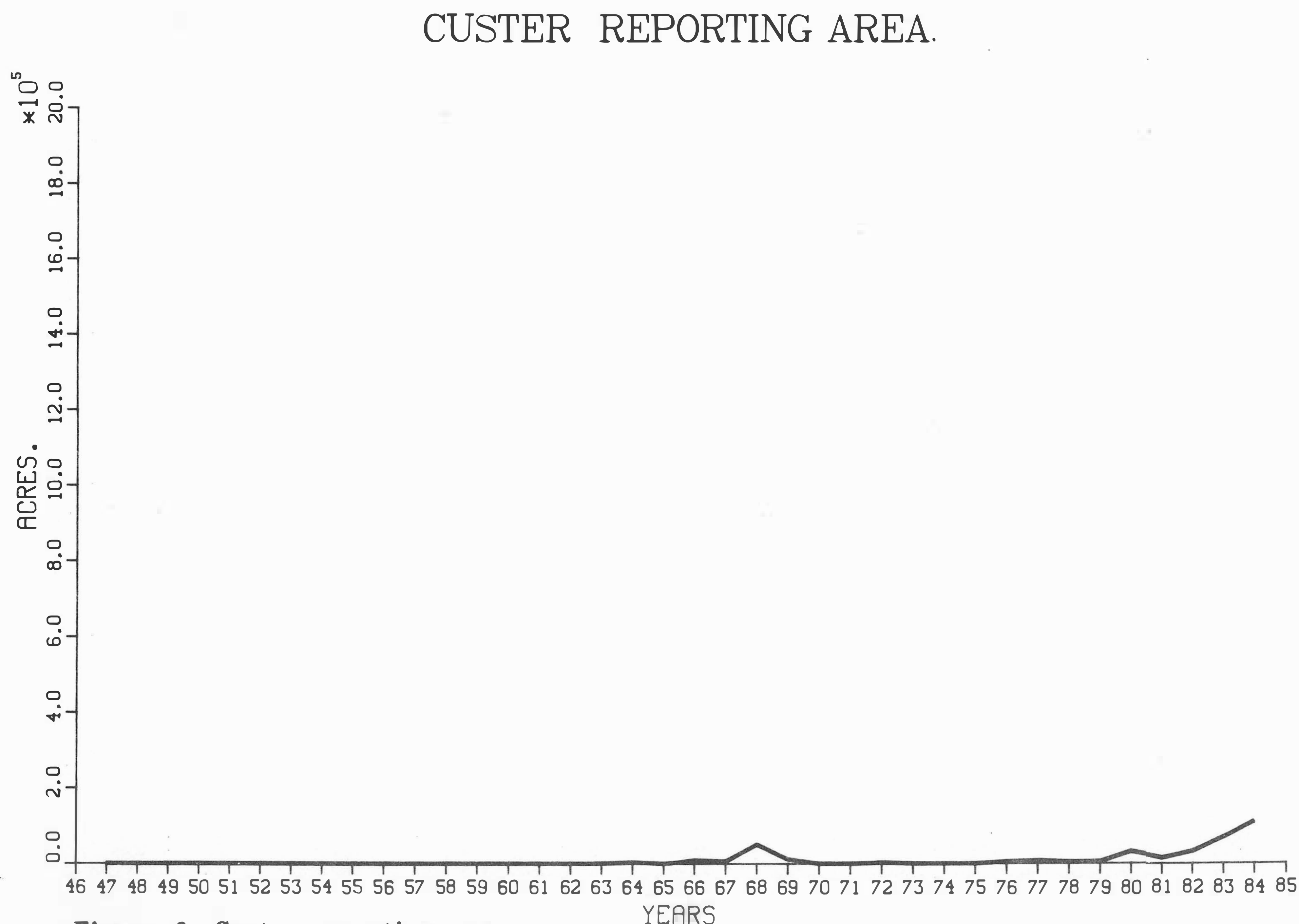

Figure 6. Custer reporting area.

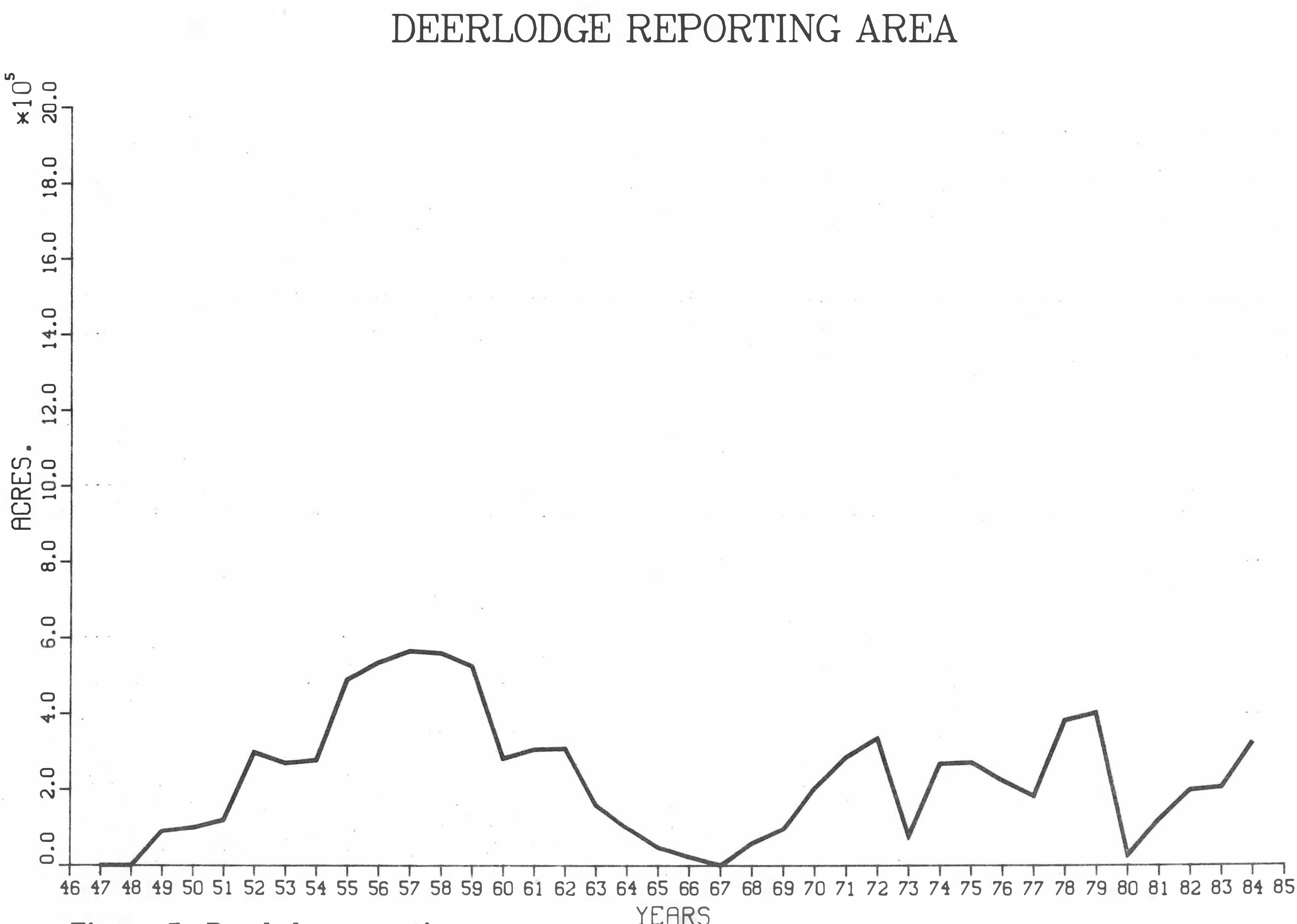

Figure 7. Deerlodge reporting area.

FLATHEAD REPORTING AREA.

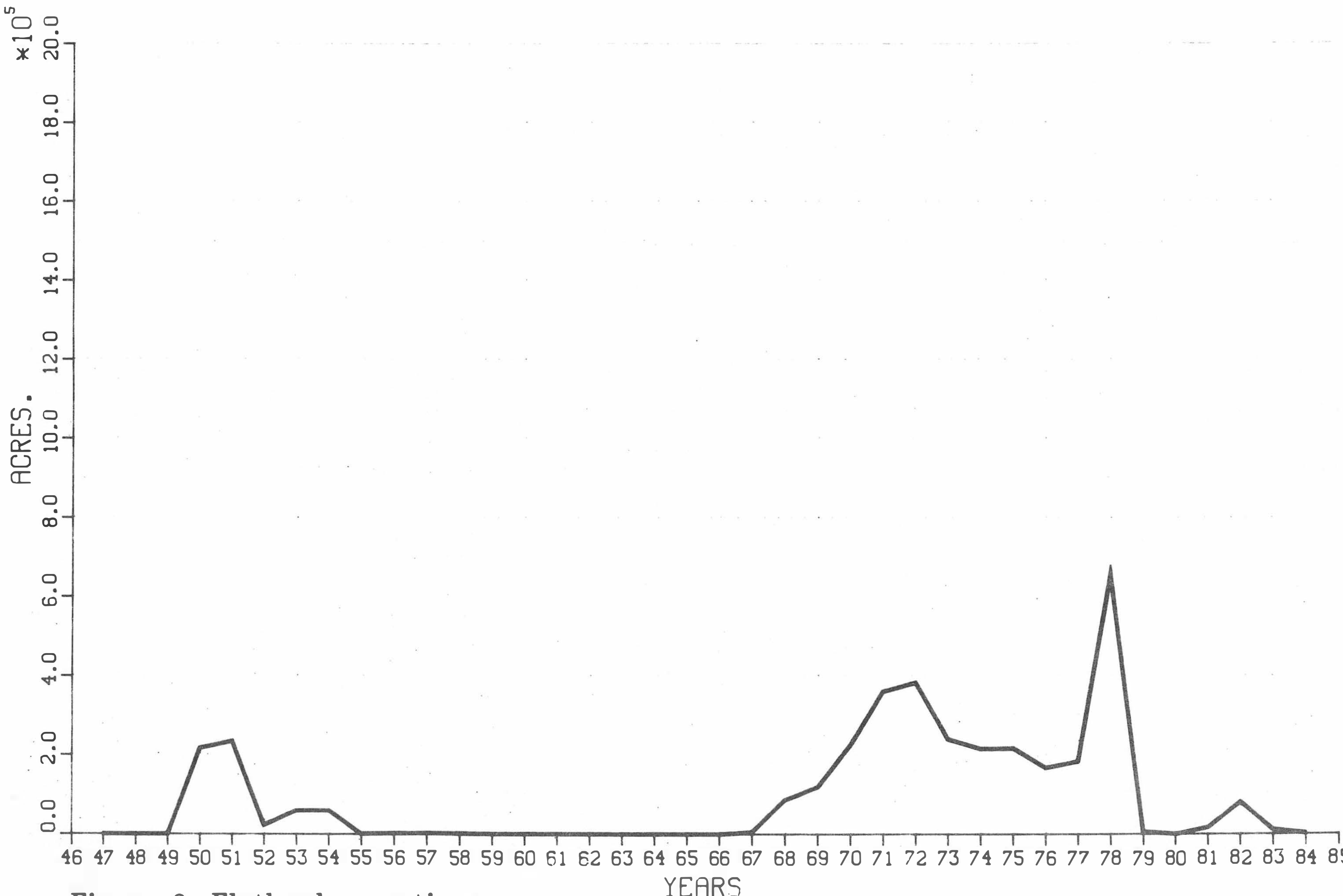

Figure 8. Flathead reporting area.

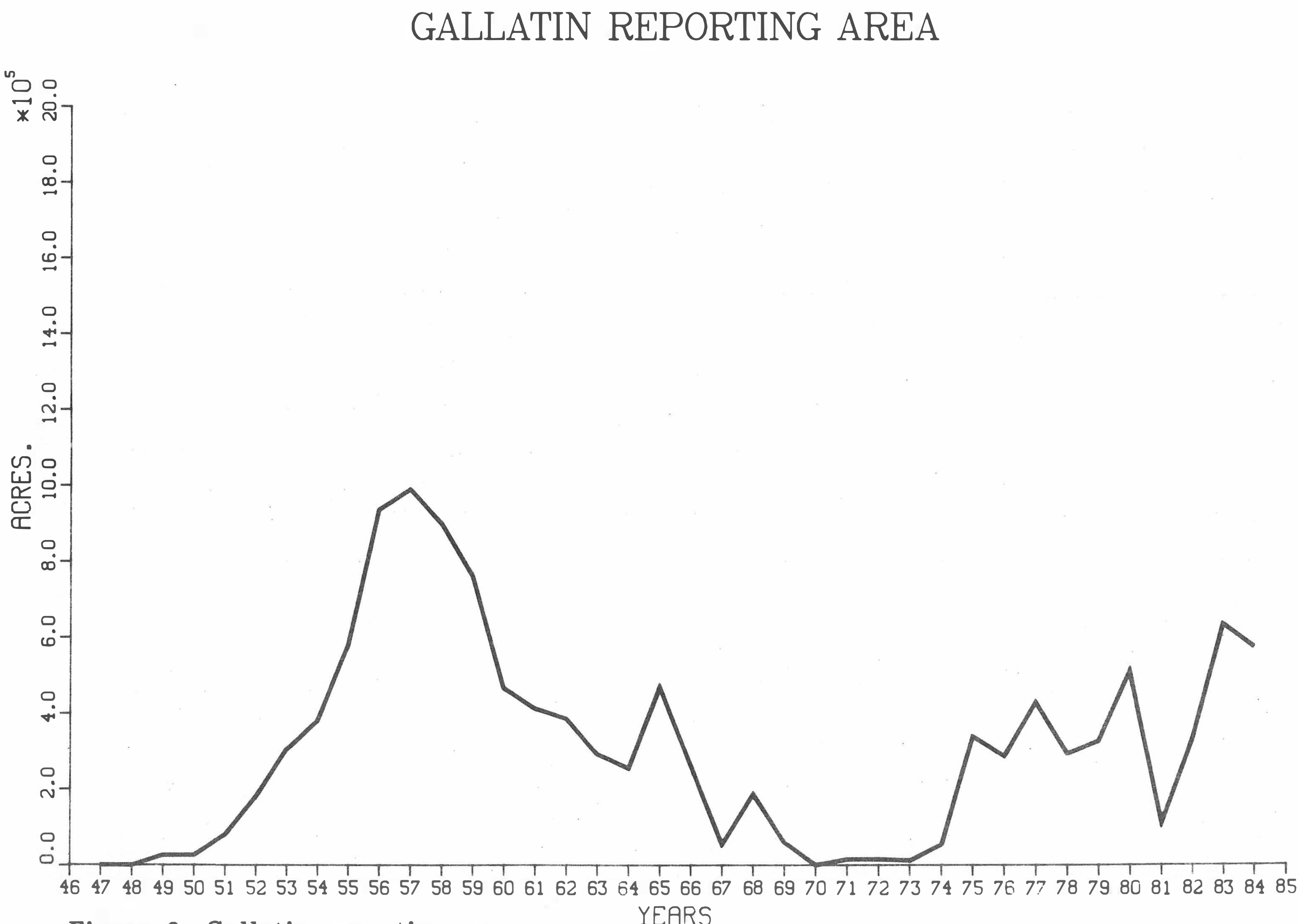

Figure 9. Gallatin reporting area.

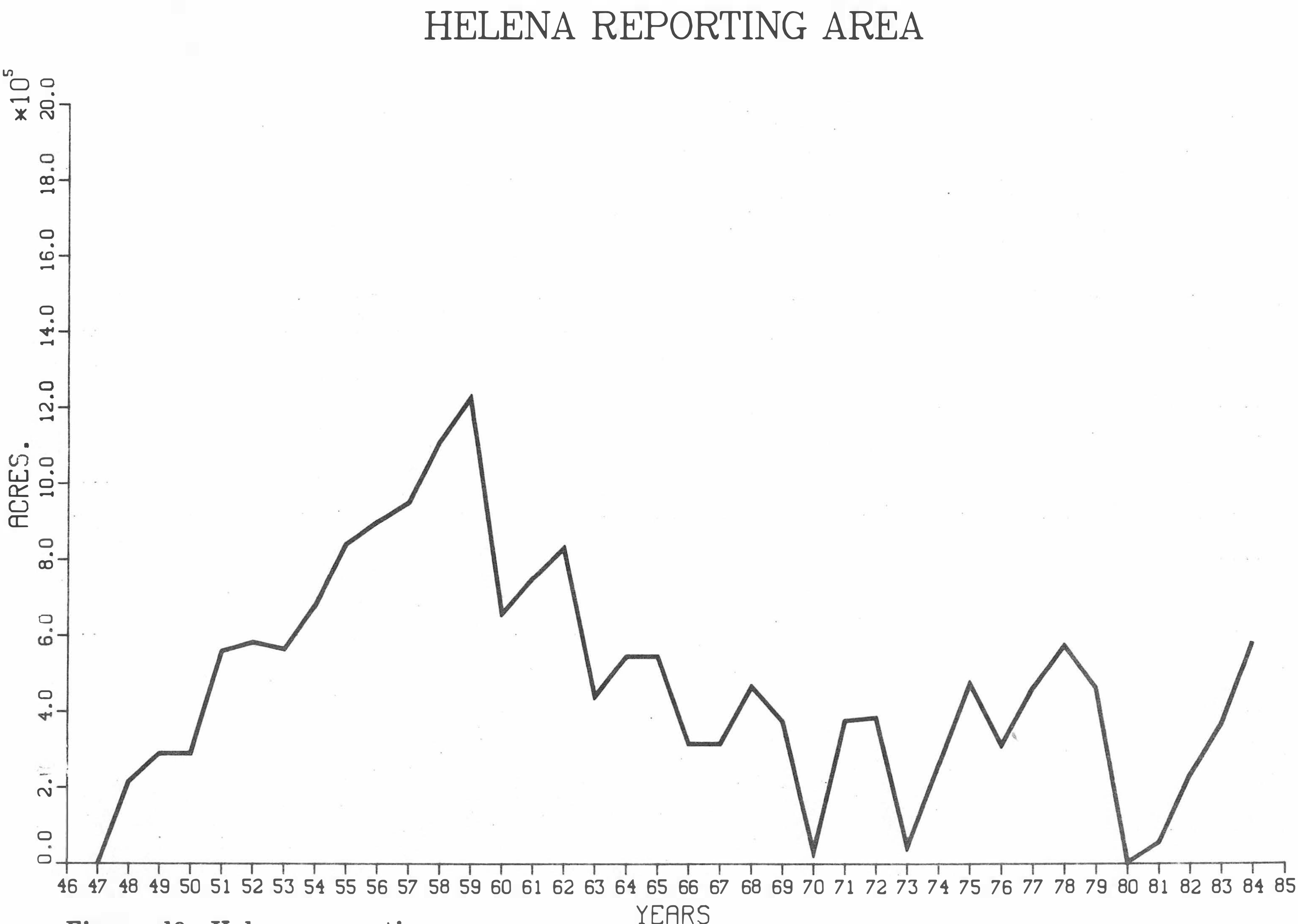

Figure 10. Helena reporting area.

KOOTENAI REPORTING AREA.

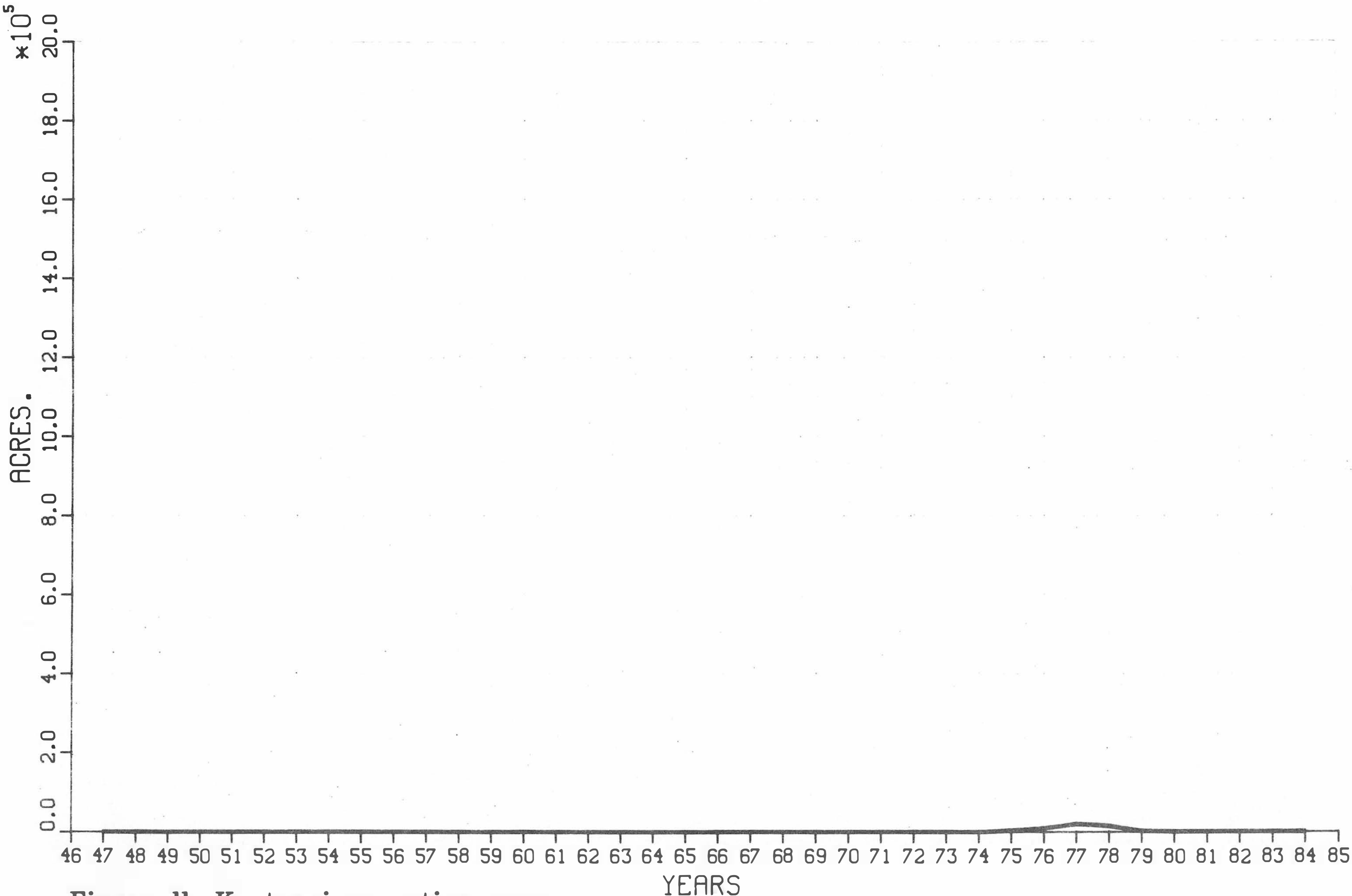

Figure 11. Kootenai reporting area.

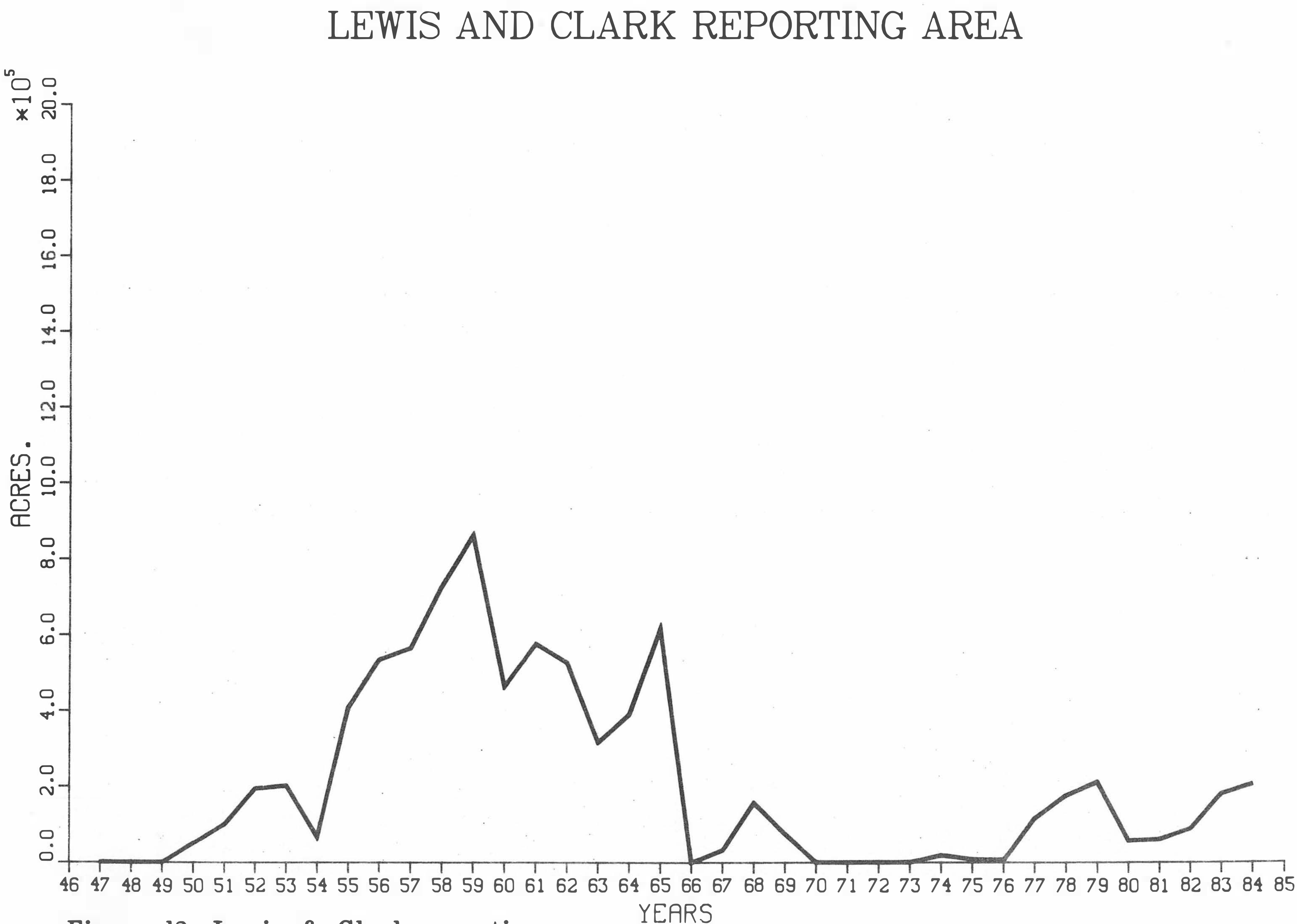

Figure 12. Lewis & Clark reporting area.

LOLO REPORTING AREA

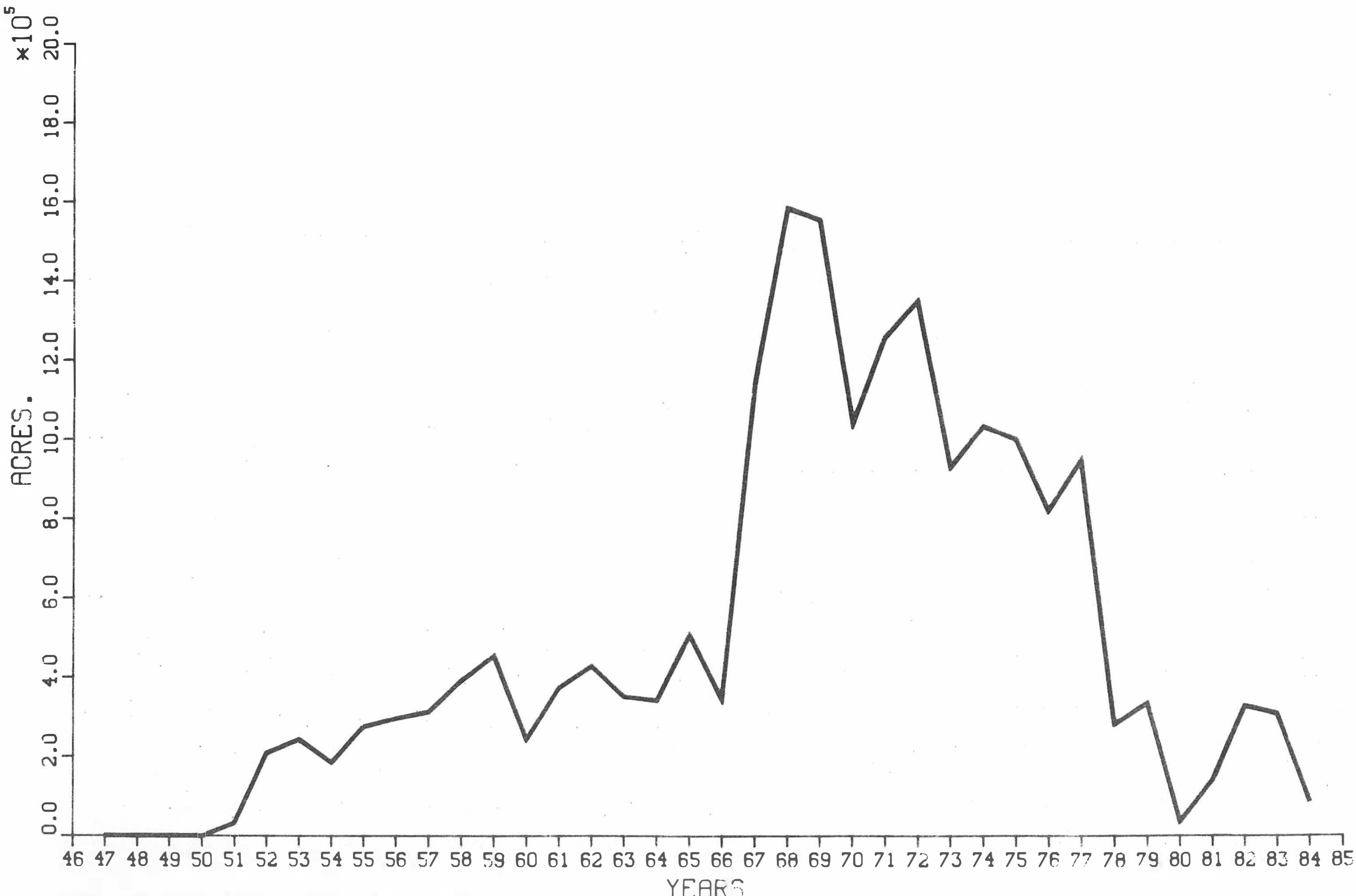

Figure 13. Lolo reporting area.

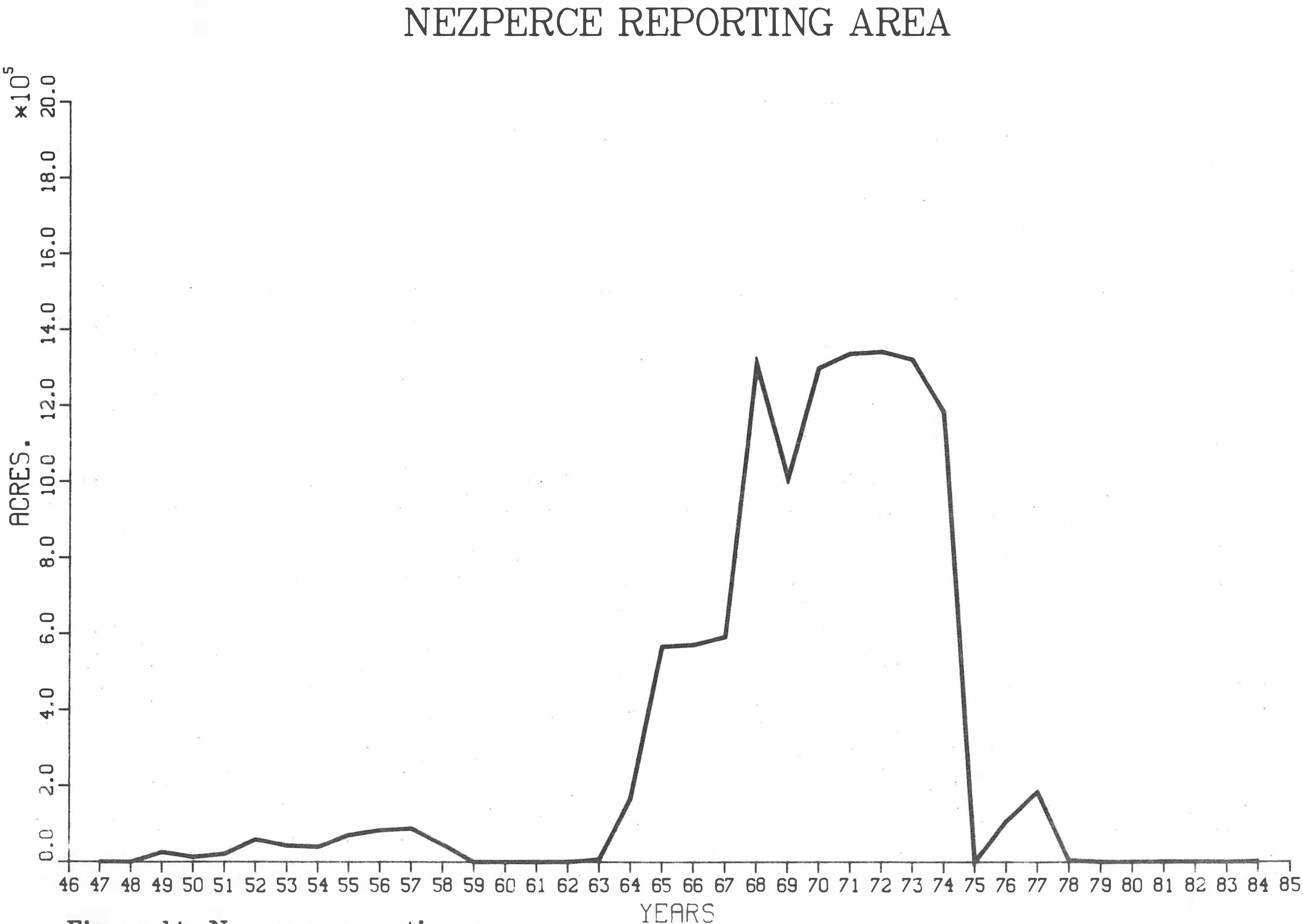

Figure 14. Nezperce reporting area.

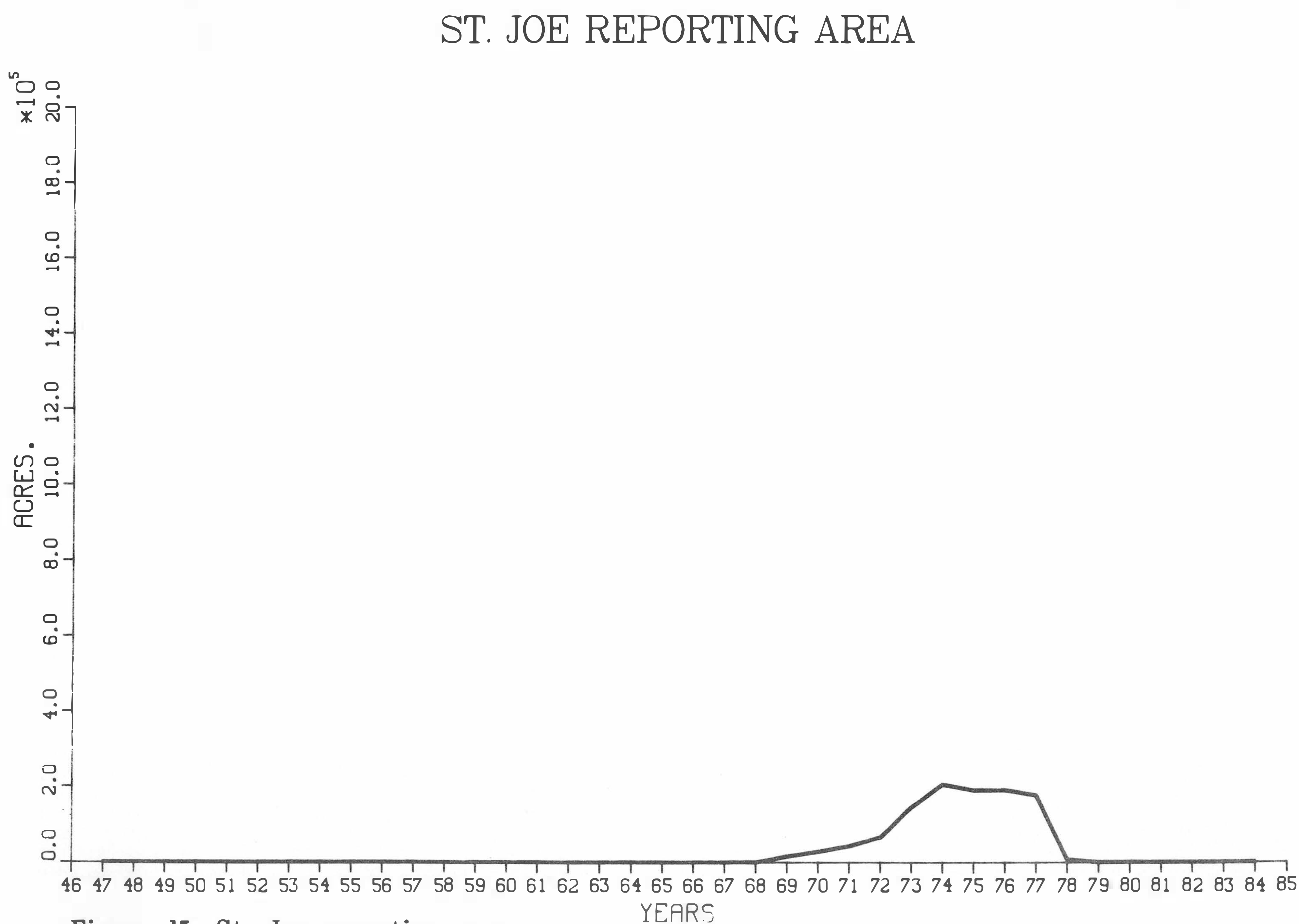

Figure 15. St. Joe reporting area.

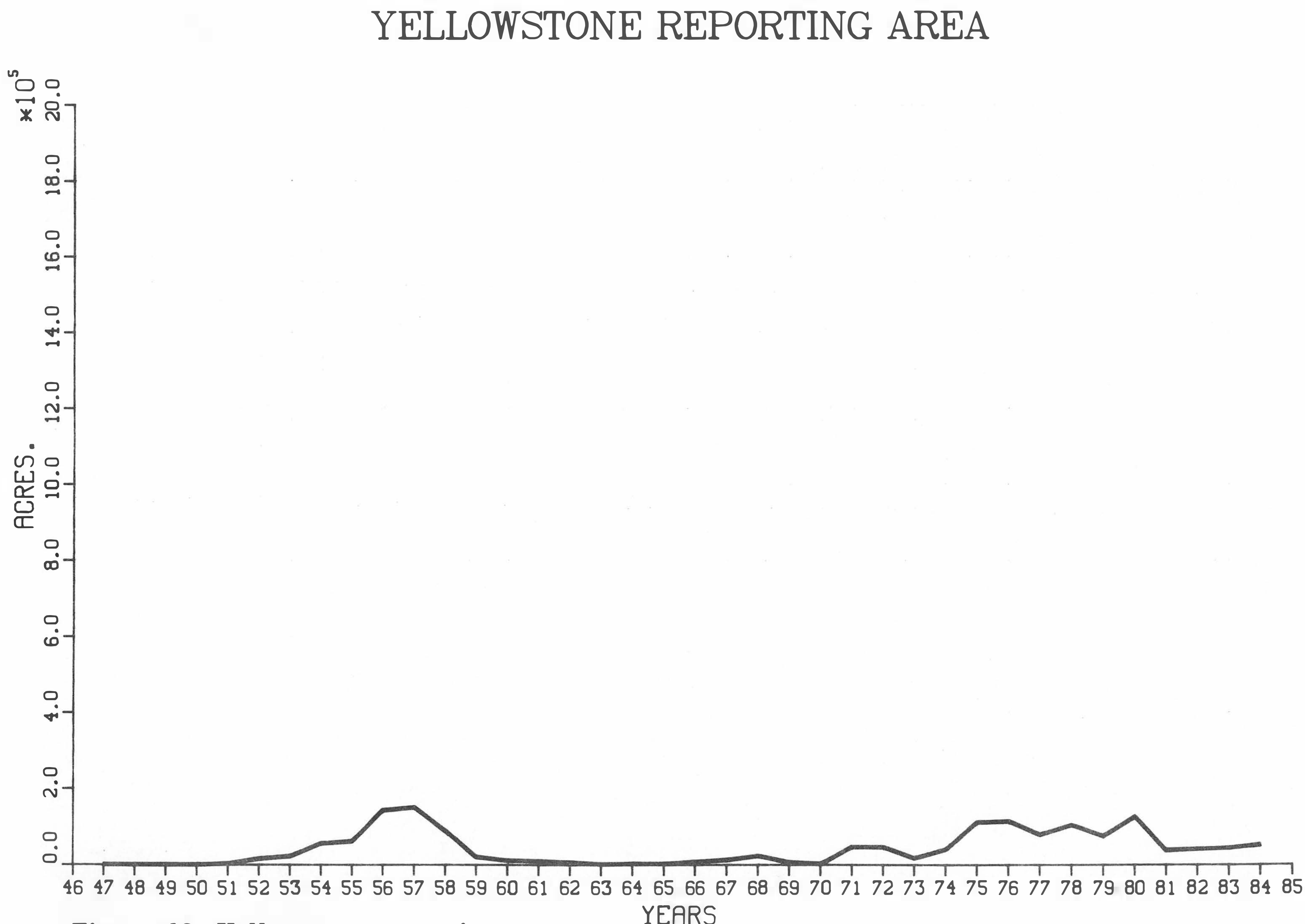

Figure 16. Yellowstone reporting area.

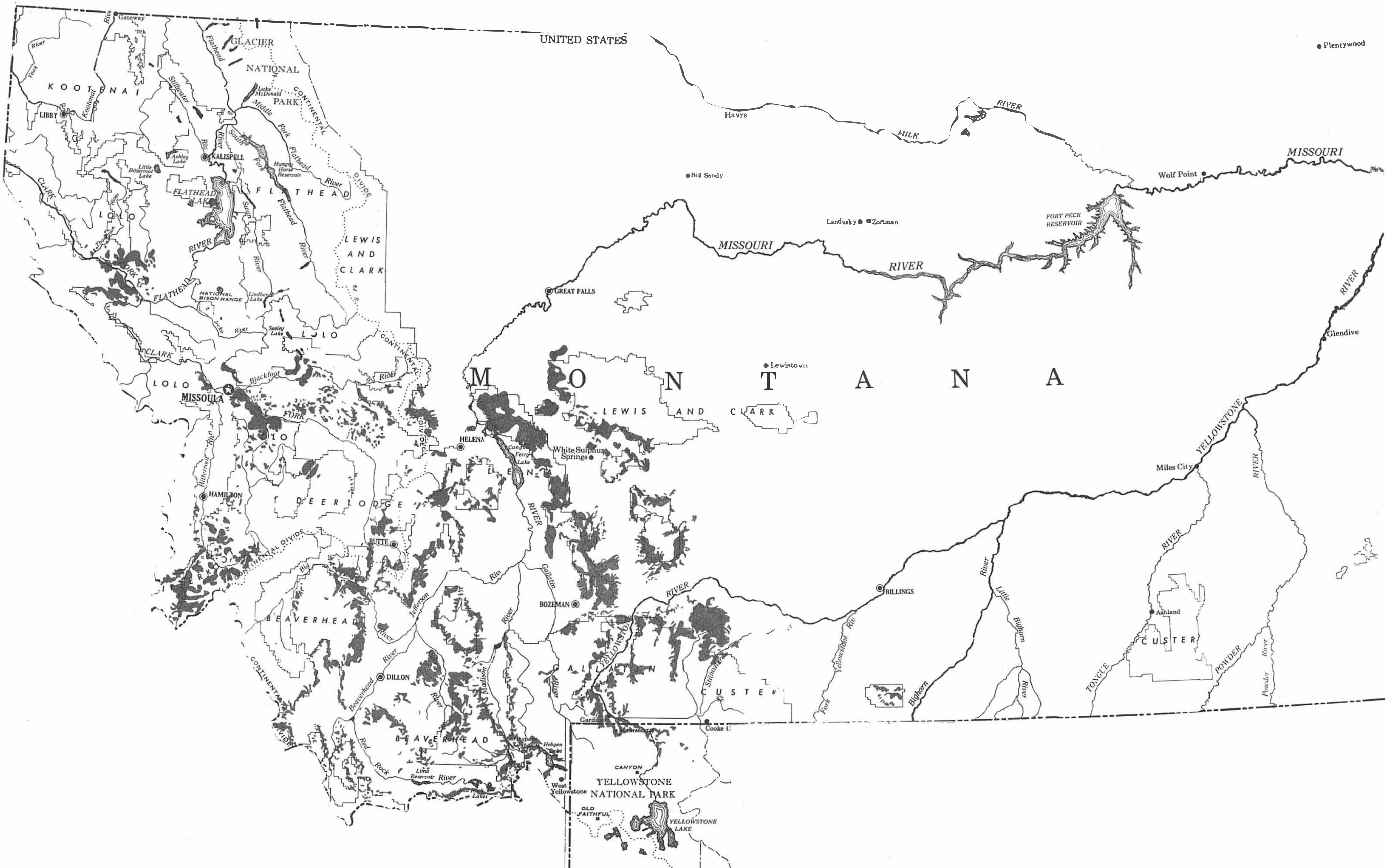

Figure 17.--Western spruce budworm defoliation visible from the air in Montana and Yellowstone National Park, 1983.

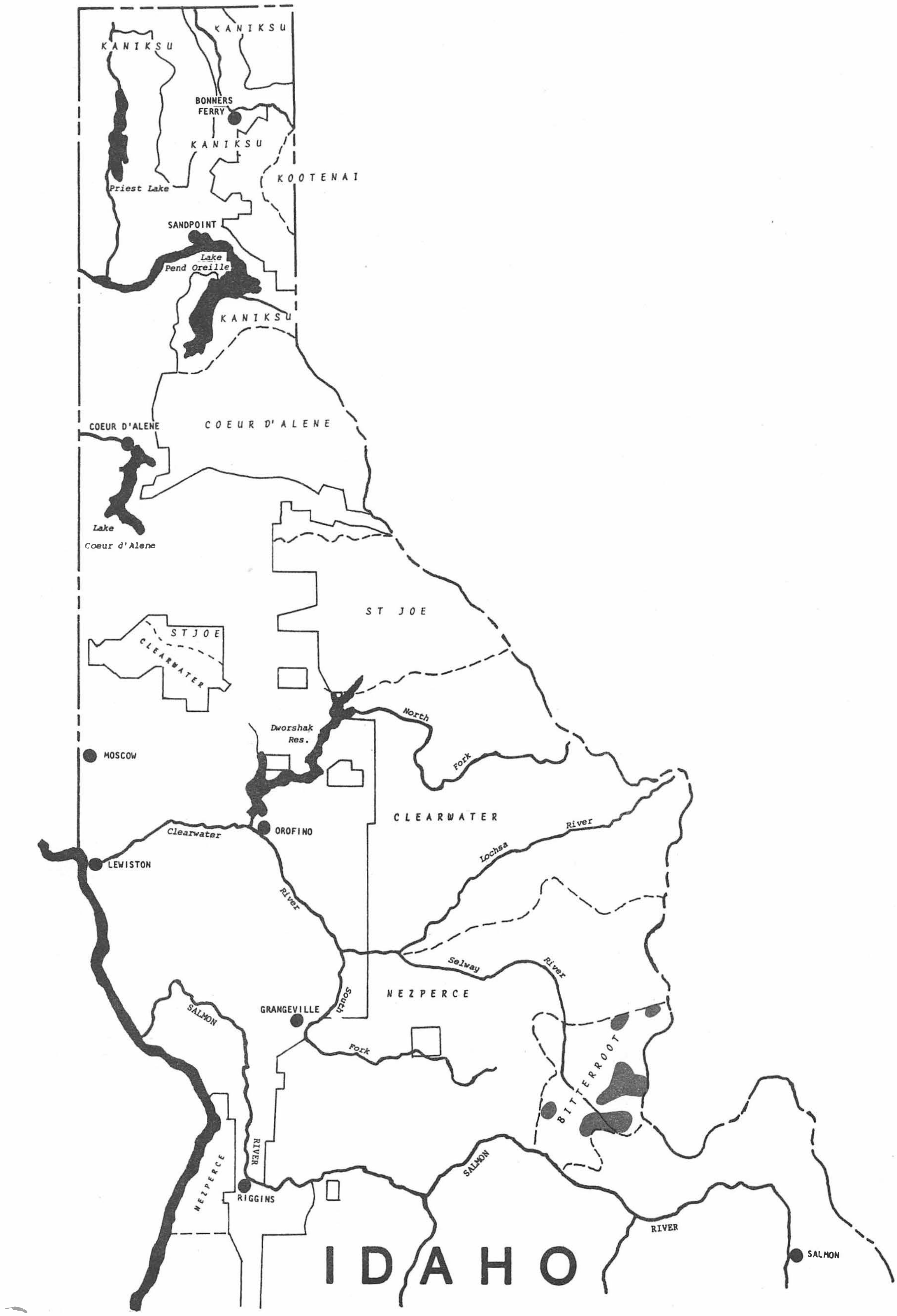

Figure 18.--Western spruce budworm defoliation visible from the air in northern Idaho, 1983.

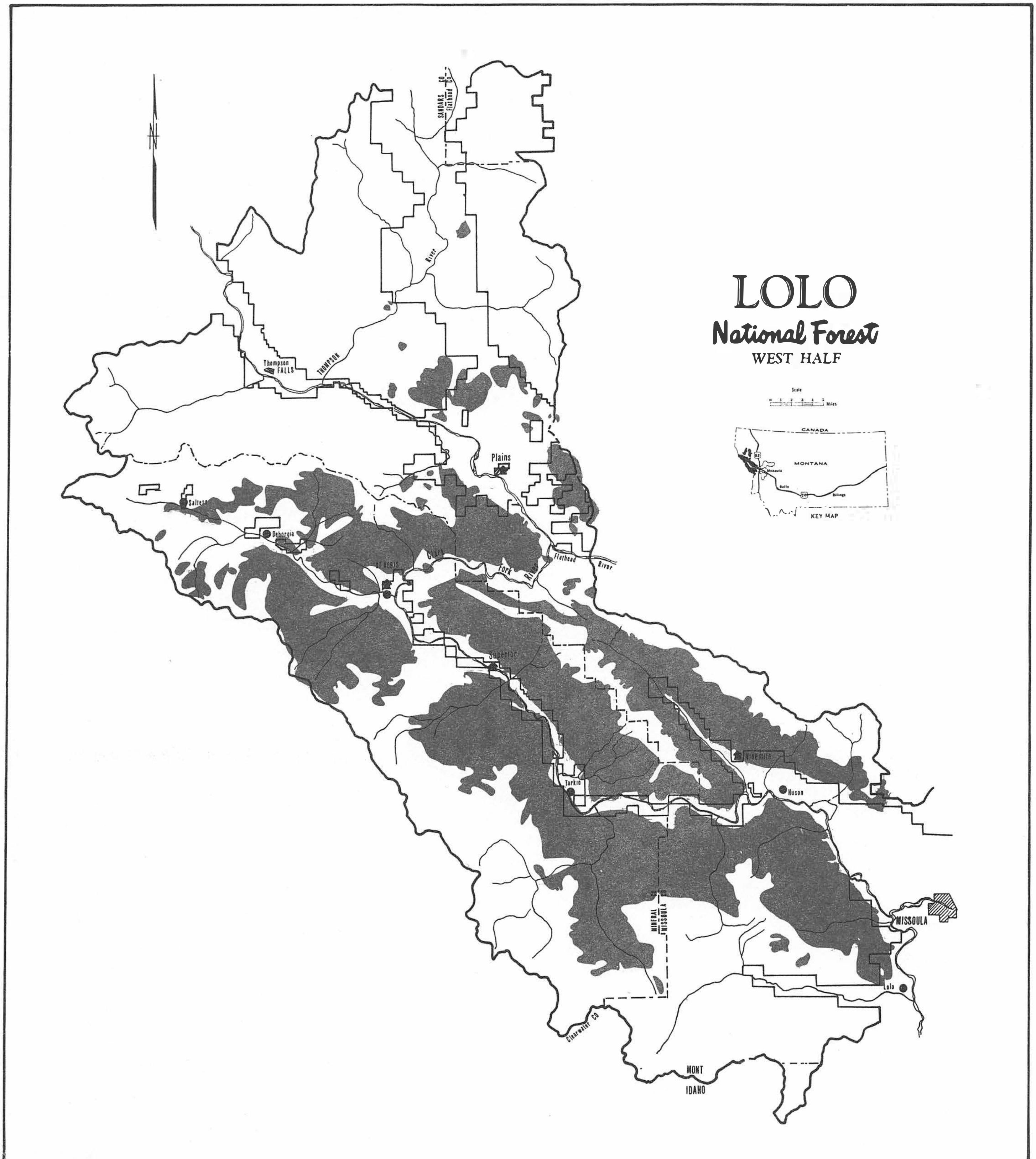

Figure 19.--Areas with three or more years defoliation between 1977 and 1983, Lolo National Forest - West.

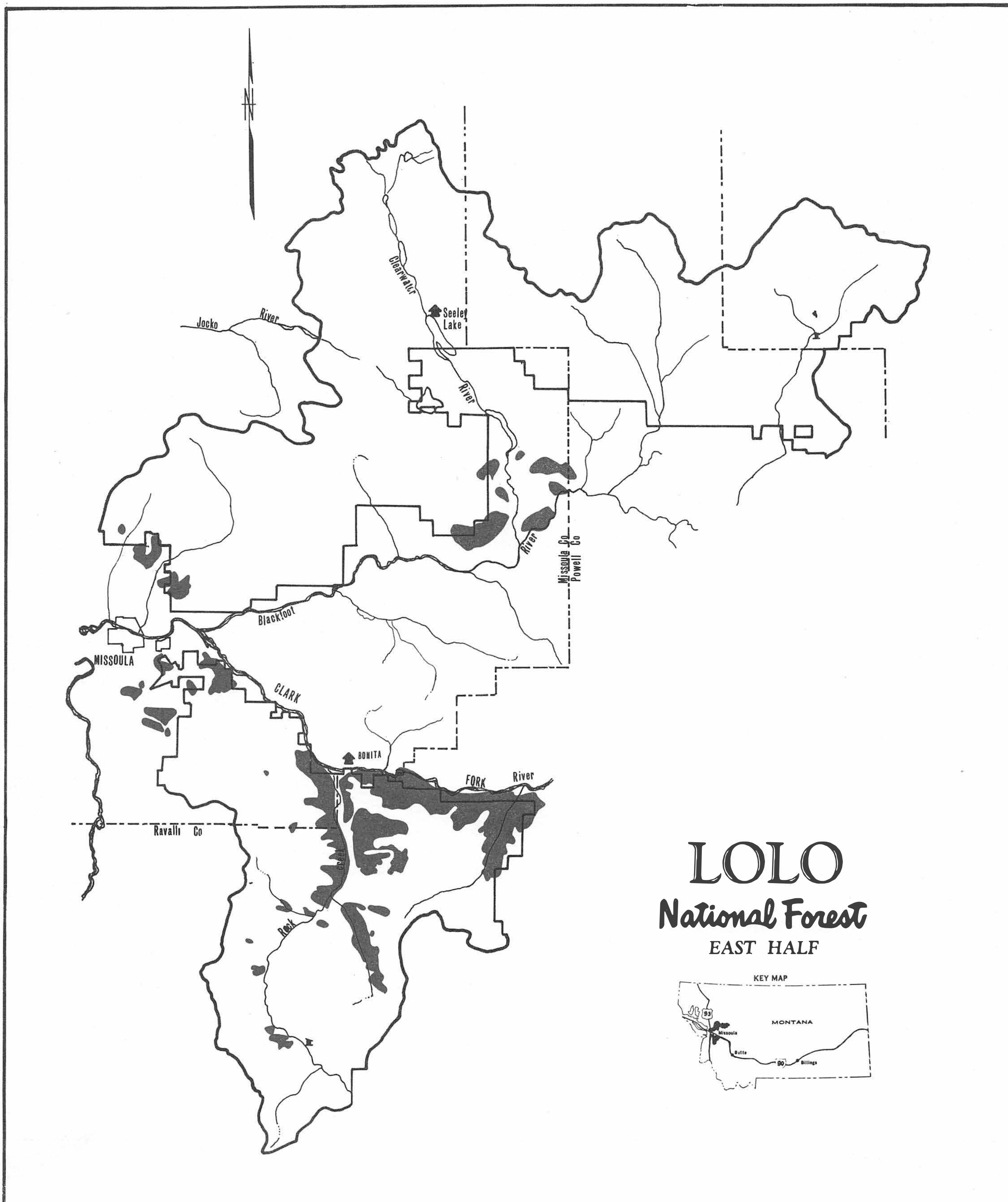

Figure 20.--Areas with three or more years defoliation between 1977 and 1983, Lolo National Forest - East (excluding Garnet Range).

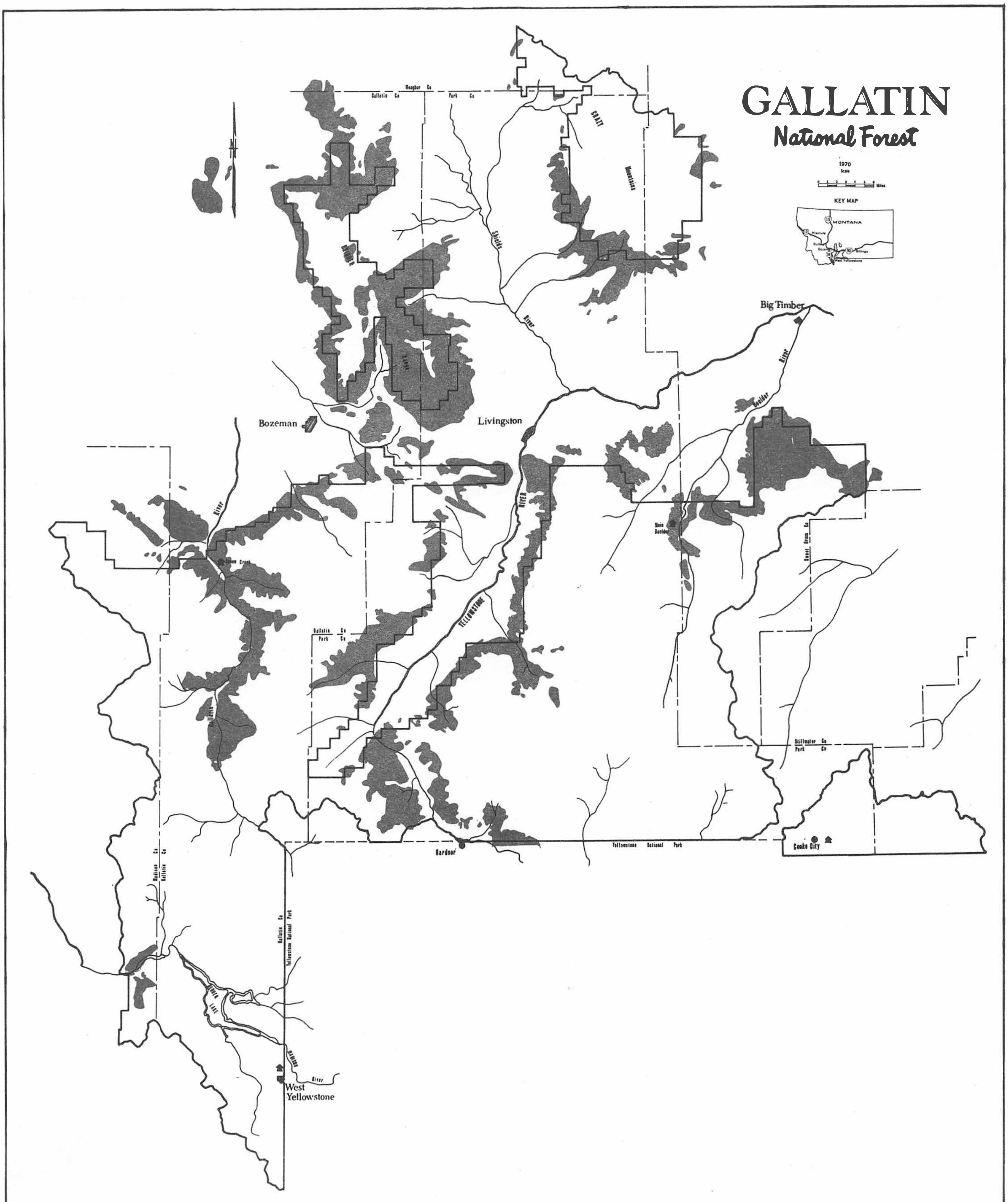

Figure 21.--Areas with three or more years defoliation between 1977 and 1983, Gallatin National Forest.

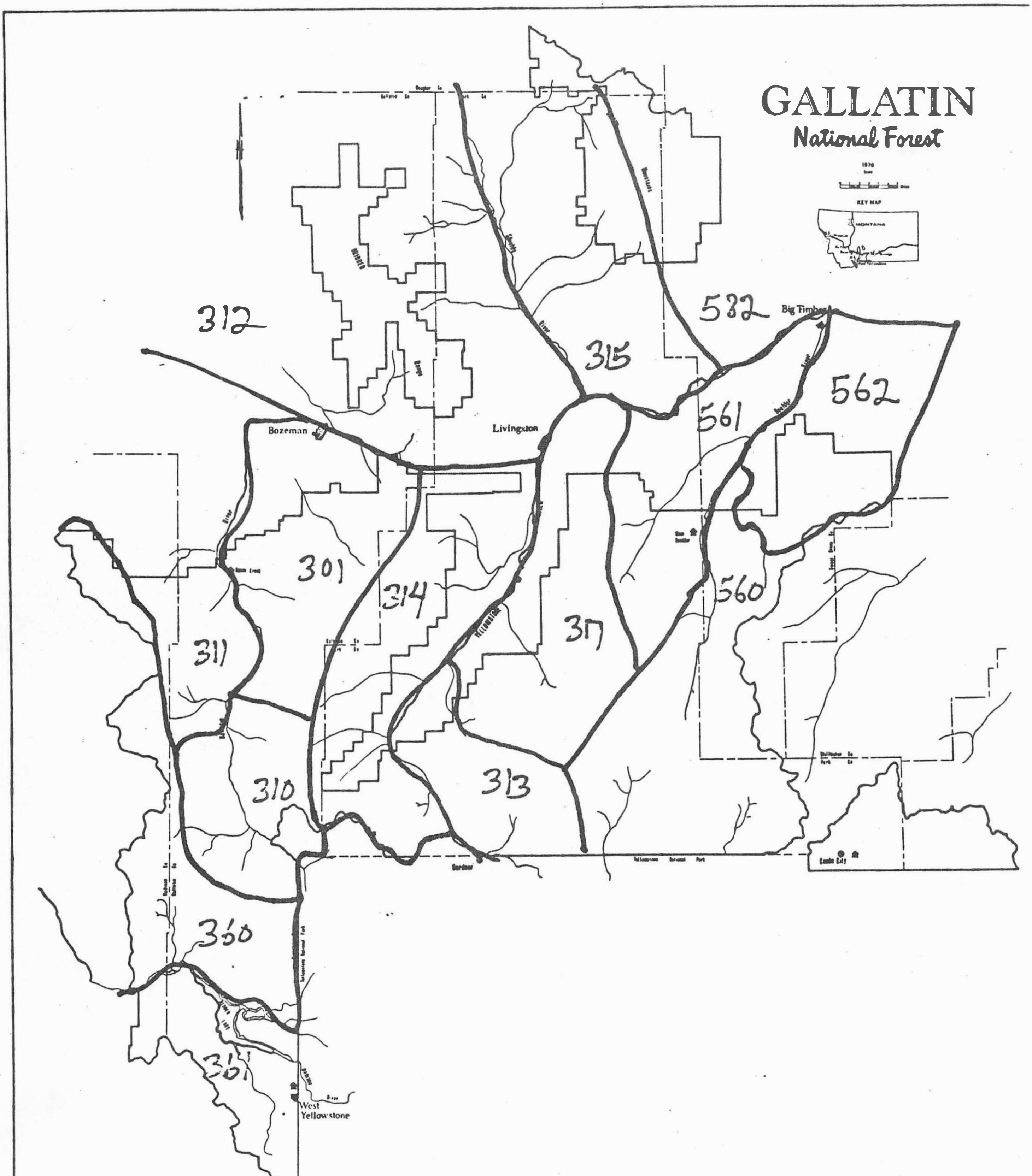

Figure 22.--Hunting districts.

ACKNOWLEDGEMENTS

We appreciate the technical advice of Jack Lyon, Intermountain Research Station, Missoula, Montana, and Jerry Light, Gallatin NF, concerning the use of various hiding cover models and their application to predict change in hunting opportunities when forest cover is altered.

Also appreciated is the assistance of Al Christopherson and Fred Stewart, Lolo NF; Richard Kracht, Sam Gilbert, and James Devitt, Gallatin NF; and Terry Raettig and Jim Laux, Regional Office, Missoula.

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Moeur, Melinda. 1981. Crown width and foliage weight of Northern Rocky Mountain conifers. USDA Forest Serv., Intmtn. Forest & Range Expt. Sta. Res. Pap. INT-283. 14 p.

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APPENDIX A

SUMMARY OF COORDINATION MEETING
WESTERN SPRUCE BUDWORM ENVIRONMENTAL ANALYSES
September 1984
Ogden, Utah

REASONABLE ALTERNATIVES FOR DEALING WITH A
WESTERN SPRUCE BUDWORM OUTBREAK

Concern — The western Regions are not consistent in their presentation of alternatives for dealing with budworm outbreaks.

Conclusion — The alternative section of NEPA documents should merely address short-range approaches to budworm management; i.e., no action versus suppression of current outbreaks. Long-range approaches should not be a part of the section of the NEPA document discussion alternatives for dealing with an outbreak. Forest Plans are the appropriate documents to rpesent long-range subjects to be included in all NEPA documents as alternatives for dealing with the current outbreak under consideration are:

1. Silvicultural practices that can suppress budworm populations and/or reduce outbreak impacts. It was concluded that some silvicultural practices may be used on relatively small areas (usually less than 1,000 acres) to reduce budworm impacts during an infestation. Silviculture is not a viable alternative for dealing immediately with an entire infestation on a large entomological unit.

2. Biological control other than microbial insecticides. Although it was concluded that this subject should be discussed as an alternative, it was agreed that it offers no opportunities at this time for budworm management. The existing Regions 3 and 6 NEPA documents provide good examples of how to address this subject.

3. Chemical and microbial insecticides. Using pesticides is the only present viable alternative for reducing budworm impacts that occur during large outbreaks.

4. Combination of silvicultural and insecticidal approaches. This approach would utilize insecticides to reduce overall impacts within entomological units, and, at the same time, apply maximum TSI and timber harvesting measures in selected areas.

Regions preparing NEPA documents should inform other Regions of alternatives being considered early in the process, and provide an opportunity for review input.

Western Regions should continue working together to become as informed as possible regarding suppression technology involving aerial spraying (buffer zones, spraying portiosn of infestations on portions of entomological units, multiple spray applications, preferred insecticides, spray systems, acceptable aircraft, etc.).

DAMAGE ESTIMATES WITH AND WITHOUT SUPPRESSION

Concern — Damage estimates with and without suppression vary between Regions.

Conclusion — Damage esitmates will vary between Regions due to species, site, and climatic conditions. However, the range is not as wide as some originally believed. Each Region is in the process of collecting site-specific data which will provide a better estimate of growth loss, growth increase, top mortality, and tree mortality. Degrade and seed production loss is also recognized as a physical effect of spruce budworm which should be qualitatively considered.

Point of agreement follow:

1. Each Region will use growth loss data from areas or plots which most nearly approximates its particular outbreak conditions.

2. Where suppression is considered before the second year of an outbreak, most growth loss can be captued as a benefit. Growth loss eventually reaches the point later in an infestation cycle where little benefit and be obtained through direct suppression.

3. Other resource values and uses at risk by the budworm canbe considered when the attainment of themanagement objectives ae threatened.

ECONOMIC ANALYSES

Concern — Regions are not using similar assumptions and methodology when making economic analyses.

Conclusion — Western Regions should utilize the following assumptiosn and methods of economic analysis to obtain consistency.

Points of agreement follow:

1. The analysis will look at a project rather than a programmatic appraoch.

2. A separate analysis will be made for analysis units such as an entomological unit.

3. A stand analysis procedure will be utilized.

4. Benefit/cost ratios and present net worth will be displayed.

5. We need to discuss the possibiliyt of retreatment during the same outbreak in the analysis process.

6. We need to discuss the possibility of subsequent outbreaks in the analysis, but this possibility will not be part of the economic analyses.

7. We will reference the fact that Forest Plans will address future drection for budworm management. The subject will be covered in all NEPA documents where Forest Plans are not approved and available to the public.

8. We need to exchange copies of NEPA documents for comment. The phase "working papers" should be put on each page.

9. We need to use a discount rate of 4 percent for determining the need for or against treatment (FSM 1971,71). Other discount rates should be obtained from FSH 190117, Chapter 1.72.

10. A qualitative discussion of the localand regional impact will be included in the analysis.

NEPA DOCUMENTATION

<u>Concern</u>

Some members of the public and some Forest Service employees are questioning the differences between REgions in prepararing NEPA documents on control of spruce budworm. These differences are especially important when one considers that the chemicals, methods and rates of application, issues, concerns, and opportunities affect environment and alternatives considered are similar.

<u>Conclusion</u>

Points of agreement follow:

1. The responsible officials will determine type and extent of documentation.

2. Methods of analysis between Regions should be similar.

3. Environmental documents will be informally reviewed between Regions.

4. Office of General Counsel should be consulted on all documents dealing with spruce budworm management.

APPENDIX C

WEIGHTED STUMPAGE VALUES FOR THE LOLO NF BY HABITAT GROUP

	Year					
Habitat group	1980	1990	2000	2010	2020	2030
1	238	304	339	394	438	490
2	225	287	319	371	414	464
3	210	268	297	347	388	435
4	192	245	272	318	357	401
5	186	237	262	308	345	388

These are delivered log values in $/MBF (1978 base year $)